SOIL SURVEY OF

Richland County, and Sheyenne National Grassland Area of Ransom County, North Dakota

United States Department of Agriculture
Soil Conservation Service and Forest Service
In cooperation with
North Dakota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1962-68. Soil names and descriptions were approved in 1970. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service and the Forest Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Soil Conservation District in Richland and Ransom Counties.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Richland County and the Sheyenne National Grassland area of Ransom County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the survey area in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site to which the soil has been assigned.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay over the soil map and colored, to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those that have a moderate limitation can be colored yellow, and those that have a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, the range sites, and the windbreak groups.

Foresters and others can refer to the section "Woodland and Windbreaks," where the soils of the survey area are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife and Recreation."

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Richland County and the Sheyenne National Grassland Area of Ransom County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the survey area given in the section "Environmental Factors Affecting Soil Use."

Cover: Aerial view of Overly-Gardena association in Richland County.

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SOIL SURVEY OF RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE AND FOREST SERVICE, IN COOPERATION WITH THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

THIS SURVEY AREA, in the southeastern part of North Dakota (fig. 1), is made up of Richland County and the Sheyenne National Grassland in the eastern part of Ransom County. The total area surveyed is 1,004,601 acres, of which 927,424 acres is Richland County and 77,177 acres is in Ransom County.

The area has a subhumid continental climate characterized by cold winters and warm summers. The growing season is long enough for all commonly grown crops to mature. The main physiographic features are the Lake Agassiz Plain, the Sheyenne Delta, which includes the Sandhills and a nearly level to hilly glacial-till plain in the southwestern part of Richland County. The Red River of the North and its south branch, the Bois de Sioux, form the eastern boundary of the survey area.

Approximately 18,350 people live in the survey area, mostly on farms and ranches or in small towns of less than 1,500 population. Wahpeton, the county seat of Richland County, is the largest town in the survey area. It has a population of 7,076. Most of the people in the area depend on the production of crops and livestock and on related agricultural enterprises for their livelihood.

About 93 percent of the survey area is in farms and ranches, and about 70 percent is used for cultivated crops. Nearly all soils of the lake plain and most soils of the till plain and the Sheyenne Delta are suited to crops and are intensively cultivated. Corn, soybeans, spring wheat, oats, and barley are the main crops. Flax and alfalfa are other important crops.

The Sheyenne Delta includes many areas of dunes where the soils are too sandy and too choppy and irregular in slope for cultivation and are used for grazing. Beef cattle production is the major enterprise for farmers and ranchers in these areas. Some small areas on the till plain are too steep, too poorly drained, or too shallow for cultivation and are used for grazing beef and dairy cattle.

In addition to the crops now grown in the survey area, the potential is high for increasing the production of sugar beets if new processing plants now in the planning stages are constructed.

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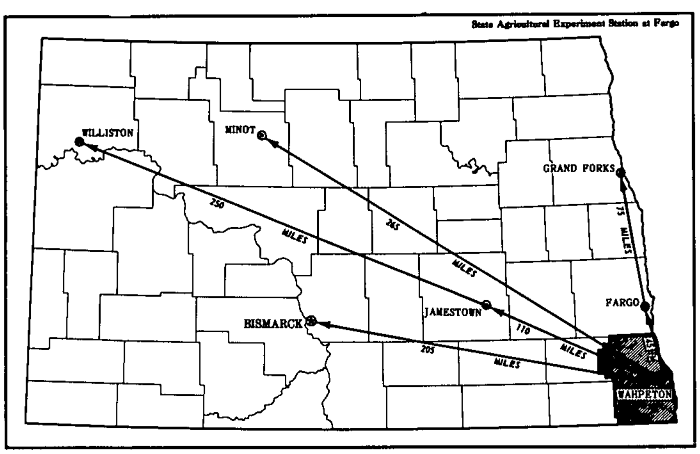

Figure 1.—**Location of Richland County and the Sheyenne National Grassland Area of Ransom County in North Dakota.**

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Richland County and the Sheyenne National Grassland Area of Ransom County, where they are located, and how they can be used. The soil scientists went into the survey area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length and shape of slopes, the size and nature of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The soil series and the soil phase are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Fargo and Wahpeton, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Fargo silty clay is one of several phases within the Fargo series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of the survey area: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Embden-Tiffany fine sandy loams is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Arveson and Fossum loams is an undifferentiated group in the survey area.

In most areas surveyed there are places where the soil material is so wet, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Marsh is a land type in this survey.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing medium for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to slow permeability or a high water table. They see that streets, road pavements, and foundations for houses crack on a given kind of soil, and they relate this failure to a high shrink-swell potential. Thus, they use observation and knowledge of soil properties, together with available research data, to predict the limitations or suitability of a soil for present and potential use.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their study and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Richland County and the Sheyenne National Grassland Area of Ransom County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The 14 soil associations in this survey have been grouped into 5 general kinds of landscapes for broad

interpretative purposes. Each of the broad groups and their included soil associations are described in the following pages. The terms for texture used in the title for all of the associations apply to the texture of the surface layer. For example, in the title of the Aastad-Forman-Svea association, the words "medium textured" refer to the texture of the surface layer.

DEEP, NEARLY LEVEL TO HILLY, WELL DRAINED AND MODERATELY WELL DRAINED, MEDIUM TEXTURED AND MODERATELY FINE TEXTURED SOILS; ON TILL PLAINS AND LAKE PLAINS

In this group are four soil associations that make up about 20 percent of the survey area. Three are on the glacial till plain and one is on the lake plain. The soils are deep, nearly level to hilly, and well drained or moderately well drained. They have a medium textured or moderately fine textured surface layer. Permeability ranges from moderate to slow, but most of the soils have moderately slow permeability. The available water capacity is high. The depth to the water table is more than 5 feet. The associations in this group are described in the following paragraphs.

1. Aastad-Forman-Svea association

Nearly level to undulating, well drained and moderately well drained, medium-textured soils formed in loamy glacial till

This soil association is on a glacial till plain in the southwestern part of Richland County. The landscape is one of swells, swales, and depressions that have differences of about 3 to 15 feet in elevation. It is mostly nearly level, but is steeper along drainageways and around the scattered, larger depressions, which occur throughout the association. Slopes are short and irregular.

This association makes up about 5 percent of the survey area. It is about 25 percent Aastad soils, 20 percent Forman soils, 20 percent Svea soils, and 35 percent soils of minor extent.

Aastad soils are on the lower slopes, are nearly level and gently undulating, and are moderately well drained. Their surface layer typically is black loam about 12 inches thick. The subsoil is very dark grayish-brown and olive-brown clay loam. The underlying material is light olive-brown, calcareous glacial till of clay loam texture.

Forman soils are on slightly rounded swells, are nearly level and undulating, and are well drained. Their surface layer typically is black loam about 7 inches thick. The subsoil is dark grayish-brown clay loam, and the underlying material is light olive-brown, calcareous glacial till of clay loam texture.

Svea soils are on lower slopes, on flats, and in swales, are nearly level to undulating, and are moderately well drained. Their surface layer typically is black loam about 11 inches thick. The subsoil is very dark gray and very dark grayish-brown loam. The underlying material is light olive-brown, calcareous loam glacial till.

Less extensive in this association are the Hamerly, Parnell, Tonka, Buse, and Gardena soils. The very poorly drained Parnell soils and the poorly drained Tonka soils are in depressions. Hamerly soils are on rims around depressions. The well-drained Buse soils are on hilltops and hillsides along drainageways and streams. The moderately well drained Gardena soils are on flats near the northern boundary of the association where lacustrine sediments overlie glacial till.

Small grain, corn, soybeans, and hay grow well on this association. Fertility and content of organic matter are high in all of the soils, and the available water capacity is high. The main concerns of management are conserving water, preventing water erosion and soil blowing, and maintaining the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

2. Forman-Aastad-Buse association

Nearly level to hilly, well drained and moderately well drained, medium-textured soils formed in loamy glacial till

This association is on a glacial till plain in the southwest corner of Richland County. The landscape is one of swells, swales, depressions, and scattered low hills and ridges. It is mostly nearly level to rolling, but is steeper around the scattered sloughs, marshes, and small lakes, which occur throughout the association. Slopes are generally short and irregular. Differences in elevation throughout most of the association range from about 10 to 60 feet within a square mile, but in some places are more than 150 feet.

This association (fig. 2) makes up about 10 percent of the survey area. It is about 35 percent Forman soils, 18 percent Aastad soils, 10 percent Buse soils, and 37 percent soils of minor extent.

Forman soils are on slightly rounded swells, are nearly level to hilly, and are well drained. Their surface layer typically is black loam about 7 inches thick. The subsoil is dark grayish-brown clay loam, and the underlying material is light olive-brown, calcareous glacial till of clay loam texture.

Aastad soils are on flats, in swales, and on lower slopes, are nearly level to undulating, and are moderately well drained. Their surface layer typically is black loam about 12 inches thick. The subsoil is very dark grayish-brown and olive-brown clay loam. The underlying material is light olive-brown, calcareous glacial till of clay loam texture.

Buse soils are on hilltops and hillsides, are moderately steep, and are well drained. Their surface layer is black loam about 6 inches thick. The underlying material is calcareous glacial till of loam or clay loam texture. In many places cultivation has mixed the light-colored underlying material with the thin surface layer.

Less extensive in this association are the Barnes, Hamerly, Parnell, and Tonka soils and many areas of Marsh. The well-drained Barnes soils are on low hills and hillsides. The poorly drained Tonka soils and very poorly drained Parnell soils are in scattered, shallow to deep depressions throughout the area. The somewhat poorly drained Hamerly soils are on the rims of shallow depressions.

Small grain, corn, soybeans, and hay grow well on this association. Fertility and content of organic matter

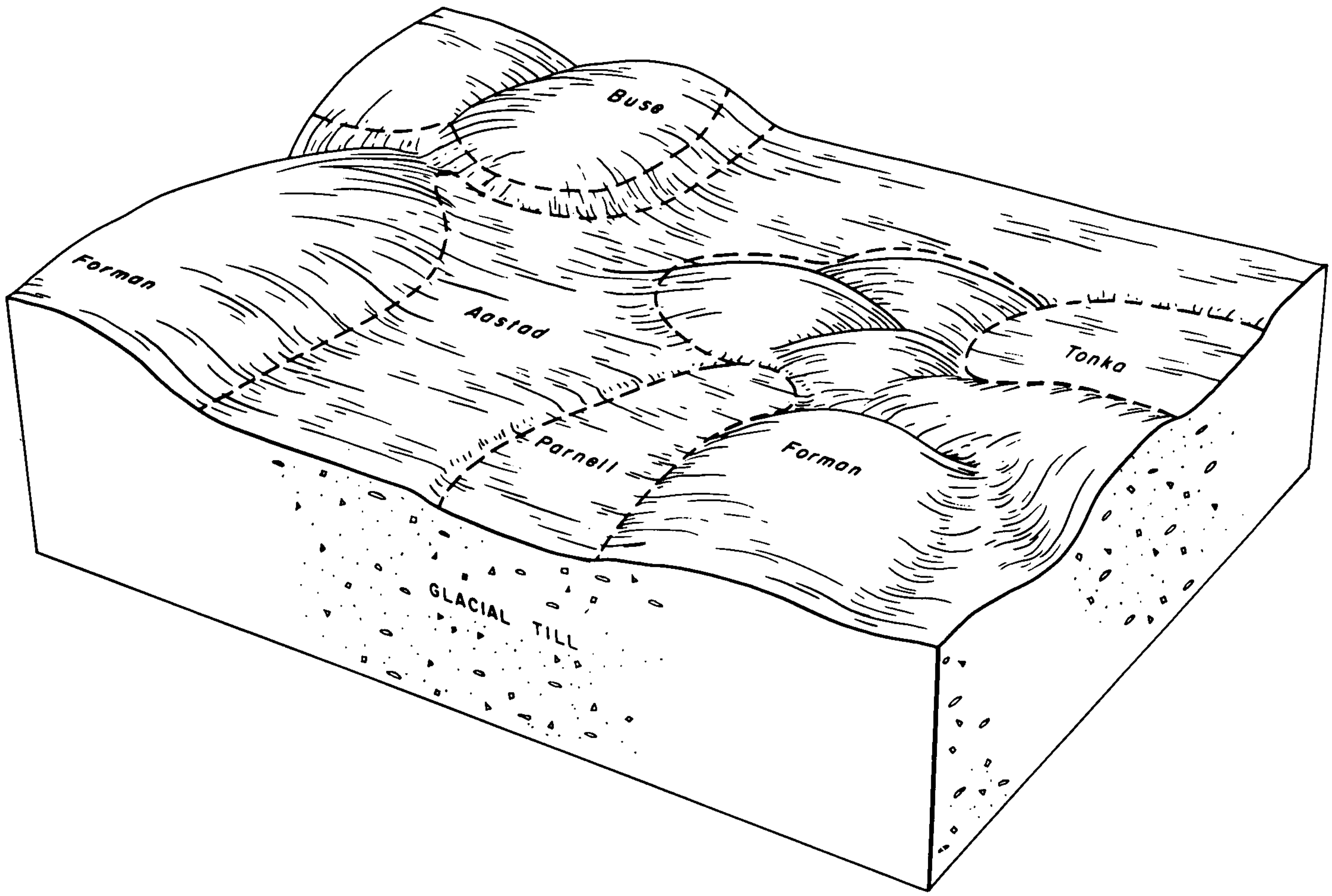

***Figure 2.*—Typical pattern of soils and parent material in association 2.**

are high in Forman and Aastad soils and low in Buse soils. The available water capacity is high in all of the soils. The main concerns of management are conserving water, preventing water erosion and soil blowing, and maintaining the level of fertility.

Nearly all of this association is used for cultivated crops. A few hilly areas and most of the wet areas are used for permanent pasture and as wildlife habitat. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

3. *Peever-Forman association*

Nearly level to undulating, well-drained, moderately fine textured soils formed in loamy glacial till

This association is on a glacial till plain in the southwestern part of Richland County. The landscape is one of swells, swales, and depressions that have differences of about 10 to 30 feet in elevation. It is mostly nearly level to undulating, but is steeper around the scattered small potholes that occur throughout the association. Slopes are short and irregular.

This association makes up less than 1 percent of the survey area. It is about 40 percent Peever soils, 30 percent Forman soils, and 30 percent soils of minor extent.

Peever soils are on the flats and lower slopes, are nearly level and undulating, and are well drained. Their surface layer typically is black clay loam about 7 inches thick. The subsoil is very dark brown, very dark grayish-brown, and olive-brown clay loam. It is underlain by light olive-brown, calcareous clay loam at a depth of about 25 inches.

Forman soils are on slightly rounded swells, are nearly level and undulating, and are well drained. Their surface layer typically is black clay loam about 7 inches thick. The subsoil is dark grayish-brown clay loam, and the underlying material is light olive-brown, calcareous glacial till of clay loam texture.

Less extensive in this association are the Buse and Parnell soils. Also included in the association are several large acreages of Marsh. The well-drained Buse soils are on hilltops and steep upper parts of hillsides. The poorly drained Parnell soils are in deep depressions.

Small grain, corn, soybeans, and alfalfa grow well on this association. Fertility and content of organic matter are high in both of the soils, and the available water capacity is high.

Most of this association is used for cultivated crops, but some small wet areas are used for pasture, hay, and wildlife. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

4. *Overly-Gardena association*

Nearly level, moderately well drained, medium textured and moderately fine textured soils formed in silty lacustrine sediments

This soil association is on a lake plain. It is mostly nearly level, but is gently sloping along streams and drainageways.

This association makes up about 5 percent of the survey area. It is about 50 percent Overly soils, 30 percent Gardena soils, and 20 percent soils of minor extent.

Overly soils are on plane and slightly convex surfaces and are moderately well drained. Their surface layer typically is black silty clay loam about 9 inches thick. The subsoil is very dark gray silty clay loam. The underlying material is calcareous, light olive-brown silty clay loam.

Gardena soils also are on plane and slightly convex surfaces and are moderately well drained. Their surface layer typically is black silt loam about 12 inches thick. The subsoil is very dark grayish-brown silt loam. The underlying material is light olive-brown, calcareous silt loam.

Less extensive in this association are the Bearden, Eckman, Perella, LaDelle, and LaPrairie soils. The somewhat poorly drained calcareous Bearden soils are on broad flats and on the rims of depressions. The well-drained Eckman soils are sloping soils along small streams and drainageways. The poorly drained Perella soils are in scattered swales and shallow depressions throughout the association. The moderately well drained LaDelle and LaPrairie soils are on bottom lands and terraces along the Wild Rice River, which flows through part of the association.

Small grain, corn, soybeans, sunflowers, sugar beets, and hay grow well on this association. The soils are well suited to all cultivated crops commonly grown in the county. Fertility and content of organic matter are high and the available water capacity is high. The main concerns of management are preventing soil blowing, conserving water, and maintaining the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

DEEP, NEARLY LEVEL TO HILLY, EXCESSIVELY DRAINED TO VERY POORLY DRAINED, COARSE-TEXTURED TO MEDIUM-TEXTURED SOILS; ON THE DELTA AND INTERBEACH AREA

In this group are two soil associations on the Sheyenne Delta and the interbeach area of the glacial lake plain. They make up about 30 percent of the survey area. The soils are deep, nearly level to hilly, and excessively drained to poorly drained. Most of the soils in this group have a coarse textured surface layer, but some of the poorly drained soils have a moderately coarse textured or a medium textured surface layer. In most of the soils permeability is rapid. The available water capacity is low. The depth to the water table ranges from more than 5 feet in the well-drained and excessively drained soils to 1 foot or less in the poorly drained soils. The associations in this group are described in the following paragraphs.

5. *Serden-Maddock association*

Gently undulating to hilly, excessively drained and well drained, coarse-textured soils formed in sandy lacustrine and eolian materials

This soil association is on the Sheyenne Delta. The landscape (fig. 3) is one of sandhills, intervening flats, shallow depressions, and swales and scattered hummocks, dunes, and blowouts. It is mostly rolling to hilly. Slopes are typically short, choppy, and complex. The Sheyenne River flows through the northern part of this association.

This association (fig. 4) makes up about 10 percent of the survey area. About 55 percent is Serden soils, 18 percent Maddock soils, and 27 percent soils of minor extent.

Serden soils are on hilltops and upper parts of hillsides and are excessively drained. Their surface layer typically is black loamy fine sand about 3 inches thick. The underlying material is very dark brown and dark grayish-brown fine sand.

Maddock soils are on slightly rounded hummocks and lower slopes and are well drained. Their surface layer typically is black loamy fine sand about 14 inches thick. The subsoil is dark-brown fine sand. The underlying material is grayish-brown and dark grayish-brown fine sand.

Less extensive in this association are the Arveson, Fossum, Hamerly, Venlo, Hecla, and Fairdale soils and small areas of stabilized duneland. The poorly drained Arveson, Fossum, and Hamar soils and the very poorly drained Venlo soils are on broad flats and in scattered depressions and swales which occur throughout the sandhills. The moderately well drained Hecla soils are on the lower slopes and in nearly level areas below the Serden and Maddock soils. The moderately well drained Fairdale soils are on bottom lands along the Sheyenne River, which flows through the association.

Native grasses grow fairly well on this association. Organic-matter content is low in the Serden soils and moderate in the Maddock soils. Fertility and available water capacity are low in both. The main concern of management is maintaining a permanent plant cover, which will prevent soil blowing and provide forage for livestock.

Nearly all of this association is used for grazing. Some small, nearly level areas are used for crops, but generally this association is unsuitable for cultivation because slopes are choppy and irregular and the hazard of soil blowing is very severe. The main enterprise is feeding beef cattle.

6. *Hecla-Hamar-Arveson association*

Nearly level to undulating, moderately well drained to very poorly drained, coarse-textured to medium-textured soils formed in sandy and loamy lacustrine sediments

This soil association is on a sandy lake plain and delta. The landscape is one of broad smooth areas, low

Figure 3.—Landscape in association 5 in the Sheyenne National Grassland.

dunes, and shallow depressions. It is mostly nearly level and undulating, but is steeper near streams and drainageways. Differences in elevation range from about 5 to 15 feet. Slopes are generally short and choppy.

This association makes up about 19 percent of the survey area. It is about 35 percent Hecla soils, 15 percent Hamar soils, 12 percent Arveson soils, and 38 percent soils of minor extent.

Hecla soils are on plane and slightly convex surfaces, are level to gently undulating, and are moderately well drained. Their surface layer is typically black fine sandy loam about 16 inches thick. Below this is a transition layer of very dark grayish-brown loamy fine sand about 6 inches thick. The underlying material is dark grayish-brown loamy fine sand and light olive-brown fine sand.

Hamar soils are in shallow depressions and on broad flats and are somewhat poorly drained or poorly drained. Their surface layer typically is black loamy fine sand about 17 inches thick. The underlying material is loamy fine sand.

Arveson soils are in shallow depressions and on broad flats and are poorly drained or very poorly drained. Their surface layer typically is black fine sandy loam or loam about 10 inches thick. The underlying material to a depth of about 20 inches is dark-gray fine sandy loam. Below this is mottled olive-gray loamy fine sand. A zone of lime accumulation is within 16 inches of the surface.

Less extensive in this association are the Maddock, Towner, Ulen, Wyndmere, Borup, and Fossum soils. The well-drained Maddock soils are on low hummocks and upper slopes. The moderately well drained Towner soils are in places where the sandy material is underlain by silty or clayey sediments. The somewhat poorly drained, calcareous Ulen and Wyndmere soils are on plane and slightly convex surfaces. The poorly drained, calcareous Borup and Fossum soils are in swales and depressions and on broad flats.

Small grain, corn, soybeans, and hay grow well on this association. Fertility is medium and the organic-matter content is high in all of the soils. The available water capacity is low or moderate. The main concerns of management are preventing soil blowing, improving drainage, and maintaining the level of fertility.

Most of this association is used for cultivated crops, but some is used for hay and pasture. The main enterprises are growing cash crops and feeding beef cattle.

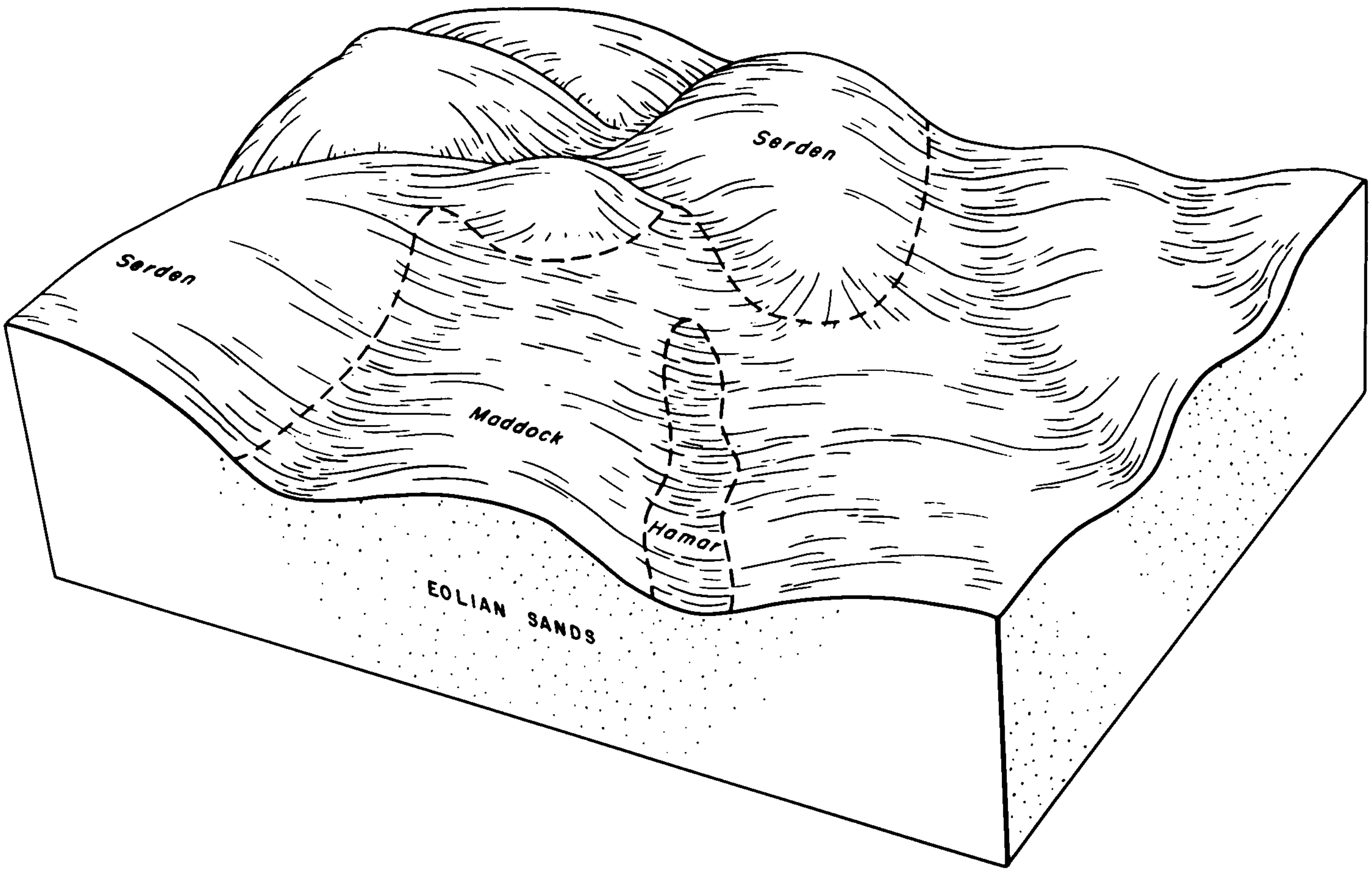

***Figure 4.*—Typical pattern of soils and parent material in association 5.**

DEEP, NEARLY LEVEL, MODERATELY WELL DRAINED TO POORLY DRAINED, MODERATELY COARSE TEXTURED AND MEDIUM TEXTURED SOILS; ON THE DELTA AND LAKE PLAIN

In this group are two soil associations on the Sheyenne Delta and the glacial lake plain. They make up about 19 percent of the survey area. The soils are deep, nearly level, and moderately well drained to poorly drained. They have a moderately coarse textured or medium textured surface layer. Permeability is moderate or moderately rapid. The available water capacity is moderate to high. The depth to the water table ranges from 1 to 3 feet in the poorly drained soils to more than 5 feet in some of the moderately well drained soils. The associations in this group are described in the following paragraphs.

7. Embden-Glyndon-Tiffany association

Nearly level, moderately well drained to poorly drained, moderately coarse textured and medium textured soils formed in loamy and silty lacustrine sediments; some are shallow over lime

This soil association is on a delta plain. It is mostly nearly level, but is undulating to rolling along streams and drainageways. Slopes are plane, convex, and concave. The difference in elevation is about 3 to 10 feet.

This association makes up about 14 percent of the survey area. It is about 35 percent Embden soils, 30 percent Glyndon soils, 15 percent Tiffany soils, and 20 percent soils of minor extent.

Embden soils are nearly level and are moderately well drained. Their surface layer typically is very dark gray fine sandy loam about 18 inches thick. The subsoil is very dark grayish-brown fine sandy loam. The underlying material is olive-brown fine sandy loam.

Glyndon soils are nearly level and somewhat poorly drained. Their surface layer typically is black silt loam and very dark gray silt loam. The underlying material is grayish-brown and light olive-brown silt loam and very fine sandy loam. A zone of lime accumulation is within 16 inches of the surface.

Tiffany soils are on broad flats and in shallow depressions, and are level and poorly drained. Their surface layer typically is about 17 inches thick. The upper part is black loam, and the lower part is very dark gray fine sandy loam. Below this is a transition layer of dark grayish-brown fine sandy loam that is mottled with dark brown. The underlying material is mottled light olive-brown and grayish-brown fine sandy loam.

Less extensive in this association are Borup, Stirum, Wyndmere, and Egeland soils. The poorly drained Bo-

rup and Stirum soils are on broad flats and in shallow depressions. The somewhat poorly drained Wyndmere soils are on plane and slightly convex surfaces. The well-drained Egeland soils are on slightly rounded upper slopes.

Small grain, corn, soybeans, sugar beets, and hay grow well on this association. Fertility is high in the Embden and Glyndon soils and medium in the Tiffany soils. The available water capacity is high in the Glyndon soils and moderate or high in the Embden and Tiffany soils. The organic-matter content is high in all of the soils. The main concerns of management are conserving water, preventing soil blowing, and maintaining the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops and feeding beef cattle.

8. *Glyndon-Gardena association*

Nearly level, moderately well drained and somewhat poorly drained, medium-textured soils formed in silty lacustrine sediments; some are shallow over lime

This soil association is on a lake plain in the southeastern part of Richland County. It is mostly nearly level, but is gently sloping along drainageways. Slopes are plane, concave, and slightly convex. Differences in elevation range from about 3 to 8 feet.

This association makes up about 4 percent of the survey area. It is about 45 percent Glyndon soils, 25 percent Gardena soils, and 30 percent soils of minor extent.

Glyndon soils are nearly level and are somewhat poorly drained. Their surface layer typically is silt loam about 15 inches thick. The upper part is black, and the lower part is very dark gray. The underlying material is grayish-brown and light olive-brown silt loam or very fine sandy loam. A zone of lime accumulation is within 16 inches of the surface.

Gardena soils are nearly level and are moderately well drained. Their surface layer typically is black silt loam about 12 inches thick. The subsoil is very dark grayish-brown silt loam. The underlying material is light olive-brown silt loam.

Less extensive in this association are the Borup, Eckman, and Gilby soils. The poorly drained calcareous Borup soils are in swales and shallow depressions and on broad flats. The well-drained Eckman soils are sloping soils along drainageways. The somewhat poorly drained, calcareous Gilby soils are on broad flats where lacustrine sediments overlie glacial till at a depth of about 20 to 36 inches.

Small grain, corn, soybeans, sugar beets, and alfalfa grow well on this association. Fertility and content of organic matter are high in all of the soils, and the available water capacity also is high. The main concerns in management are conserving water, preventing soil blowing, and maintaining the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops and dairying.

DEEP, NEARLY LEVEL, SOMEWHAT POORLY DRAINED AND POORLY DRAINED, MEDIUM-TEXTURED TO FINE-TEXTURED SOILS; ON THE LAKE PLAIN

In this group are five soil associations on the Lake Agassiz Plain. They make up about 31 percent of the survey area. The soils are deep, nearly level, and somewhat poorly drained to poorly drained. Most of the soils have a moderately fine textured or fine textured surface layer, but some of the associated soils have a medium textured surface layer. Some of the soils have a sodic claypan subsoil. Permeability is slow or very slow. All but the soils that have a claypan subsoil have high available water capacity. The depth to a seasonal high water table ranges from 1 to 3 feet.

The soil associations in this group are described in the following paragraphs.

9. *Fargo association*

Nearly level, poorly drained, fine-textured soils formed in clayey lacustrine sediments

This soil association is on a lake plain. It is mostly nearly level, but is steeper along streams and drainageways. The surface is plane and slightly concave. Differences in elevation range from about 1 to 5 feet.

This association makes up about 7 percent of the survey area. It is about 85 percent Fargo soils and about 15 percent soils of minor extent.

Fargo soils are nearly level and poorly drained. Their surface layer typically is black silty clay about 8 inches thick. The subsoil is very dark gray clay, and the underlying material is olive-gray clay.

Less extensive in this association are the Dovray, Grano, Hegne, Wahpeton, and Cashel soils. The very poorly drained Dovray and Grano soils are in the deepest swales and depressions. The poorly drained, calcareous Hegne soils are on slightly convex surfaces. The moderately well drained Wahpeton soils and the somewhat poorly drained Cashel soils are on terraces and bottom lands of the Wild Rice and Red Rivers that flow through parts of this association.

Small grain, corn, soybeans, sugar beets, and alfalfa grow well on this association. Fertility, organic-matter content, and the available water capacity are high. The main concerns of management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

10. *Fargo-Hegne association*

Nearly level, poorly drained, fine-textured soils formed in clayey lacustrine sediments; some are shallow over lime

This soil association is on a lake plain. It is mostly nearly level, but is slightly steeper along streams and drainageways. The surface is plane, concave, and slightly convex. Differences in elevation range from about 1 to 5 feet.

This association makes up about 3 percent of the survey area. It is about 65 percent Fargo soils, 20 percent Hegne soils, and 15 percent soils of minor extent.

Fargo soils are on plane and slightly concave surfaces, are nearly level, and are poorly drained. Their surface layer typically is black silty clay about 8 inches thick. The subsoil is very dark gray clay. The underlying material is olive-gray clay.

Hegne soils are on slightly convex surfaces, are nearly level, and are poorly drained. Their surface layer typically is black silty clay about 8 inches thick. The underlying material is dark-gray and olive-gray silty clay. A zone of lime accumulation is within 16 inches of the surface.

Less extensive in this association are the Grano, Dovray, Wahpeton, Cashel, and Bearden soils. The very poorly drained Grano and Dovray soils are in the deepest depressions. The moderately well drained Wahpeton soils and the somewhat poorly drained Cashel soils are on terraces and bottom lands along the Bois de Sioux and Red Rivers which flow through parts of the association. The somewhat poorly drained, calcareous Bearden soils are on plane and slightly convex surfaces in areas where the underlying material is silty clay loam.

Small grain, corn, soybeans, sugar beets, and alfalfa grow well on this association. Fertility, organic-matter content, and the available water capacity are high. The main concerns of management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

11. Fargo-Ryan association

Nearly level, poorly drained, fine textured and moderately fine textured soils formed in clayey lacustrine sediments; some are very shallow over a sodic claypan subsoil

This soil association is on a lake plain. It is mostly nearly level, but is steeper along streams and drainageways. The surface is plane and slightly concave. Differences in elevation range from about 1 to 5 feet.

This association makes up about 8 percent of the survey area. It is about 55 percent Fargo soils, 25 percent Ryan soils, and 20 percent soils of minor extent.

Fargo soils are nearly level and poorly drained. Their surface layer typically is black silty clay about 8 inches thick. The subsoil is very dark gray clay. The underlying material is olive-gray clay.

Ryan soils are nearly level and poorly drained and have a sodic claypan subsoil. Their surface layer typically is very dark gray silty clay loam about 5 inches thick. The subsoil is very dark brown and very dark gray silty clay that contains a high level of sodium salts. The underlying material is dark grayish-brown and olive-gray silty clay.

Less extensive in this association are the Enloe, Dovray, LaDelle, and Wahpeton soils. The poorly drained Enloe and the very poorly drained Dovray soils are in the deepest depressions and swales. The moderately well drained LaDelle and Wahpeton soils are on terraces and bottom lands of the Wild Rice River that flows through this association.

Small grain, soybeans, and hay grow fairly well on this association. Fertility is high in the Fargo soils, but it is low in the Ryan soils. Organic-matter content is high in all of the soils. The available water capacity is high in the Fargo soils and moderate in the Ryan soils. The main concerns of management are maintaining tilth and the level of fertility, removing excess water, and preventing soil blowing.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

12. Galchutt-Fargo-Aberdeen association

Nearly level, somewhat poorly drained and poorly drained, medium textured to moderately fine textured soils formed in silty and clayey lacustrine sediments; some are shallow over a sodic claypan subsoil

This soil association is on a lake plain. It is mostly nearly level, but is steeper along streams and drainageways. The surface is plane, concave, or slightly convex. Differences in elevation range from about 1 to 5 feet.

This association makes up about 6 percent of the survey area. It is about 35 percent Galchutt soils, 30 percent Fargo soils, 15 percent Aberdeen soils, and about 20 percent soils of minor extent.

Galchutt soils are nearly level and are somewhat poorly drained. Their surface layer typically is black silt loam about 16 inches thick. The subsurface layer is very dark grayish-brown silt loam about 9 inches thick. The subsoil and underlying material are clay.

Fargo soils are nearly level and are poorly drained. Their surface layer typically is black silty clay about 8 inches thick. The subsoil is very dark gray silty clay, and the underlying material is olive-gray silty clay.

Aberdeen soils are nearly level and somewhat poorly drained, and they have a sodic claypan subsoil. Their surface layer typically is black silty clay loam about 9 inches thick. The subsurface layer is very dark gray silt loam about 2 inches thick. The subsoil is very dark brown and very dark grayish-brown clay, and the underlying material is olive-gray silty clay.

Less extensive in this association are the Bearden, Overly, and Perella soils. The poorly drained Perella soils are on flats and in swales and shallow depressions. The moderately well drained Overly soils and the somewhat poorly drained Bearden soils are on plane and slightly convex surfaces.

Small grain, corn, soybeans, and alfalfa grow well on this association. Fertility is high in the Galchutt and Fargo soils and medium in the Aberdeen soils. The organic-matter content and available water capacity are high in all of the soils. The main concerns of management are improving drainage, preventing soil blowing, and maintaining the level of fertility.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

13. Antler-Doran-Tonka association

Nearly level, somewhat poorly drained and poorly drained, moderately fine textured soils formed in loamy and silty lacustrine sediments and the underlying loamy glacial till; some are shallow over lime

This soil association is on a lake plain in the eastern part of Richland County. It is mainly nearly level. The surface is plane, concave, or convex. Differences in elevation range from about 2 to 7 feet.

This association makes up about 7 percent of the survey area. It is about 35 percent Antler soils, 25 percent Doran soils, 10 percent Tonka soils, and 30 percent soils of minor extent.

Antler soils are nearly level and somewhat poorly drained. Their surface layer typically is black silty clay loam about 10 inches thick. The underlying material is dark-gray silty clay loam about 6 inches thick. Below this is grayish-brown and light olive-brown glacial till of clay loam texture. A zone of lime accumulation is within 16 inches of the surface.

Doran soils are nearly level and somewhat poorly drained. Their surface layer typically is black clay loam about 9 inches thick. The upper part of the subsoil is very dark grayish-brown clay and the lower part is olive-brown clay loam. The underlying material is grayish-brown and dark grayish-brown glacial till of clay loam texture.

Tonka soils are in shallow depressions and swales and are poorly drained. Their surface layer typically is black silt loam about 12 inches thick. The subsurface layer is very dark gray silt loam. The subsoil is very dark gray silty clay loam, and the underlying material is silt loam to clay loam.

Less extensive in this association are the Perella, Vallers, and Roliss soils. The poorly drained Perella soils are in shallow depressions and swales. The poorly drained, calcareous Vallers soils are on the rims of shallow depressions. The very poorly drained, calcareous Roliss soils are on broad flats and in shallow depressions.

Small grain, corn, soybeans, and alfalfa grow well on this association. Fertility, content of organic matter, and the available water capacity are high in all of the soils. The main concerns of management are removing excess water, maintaining the level of fertility, and preventing soil blowing.

Nearly all of this association is used for cultivated crops. The main enterprises are growing cash crops, dairying, and feeding beef cattle.

SHALLOW AND MODERATELY DEEP, NEARLY LEVEL TO GENTLY SLOPING, EXCESSIVELY DRAINED AND WELL DRAINED SOILS THAT ARE LESS THAN 36 INCHES DEEP TO COARSE SAND AND GRAVEL; ON BEACH RIDGES

The one soil association in this group is on beach ridges on the glacial lake plain. It makes up less than 1 percent of the survey area. The soils in this association are shallow and moderately deep, nearly level to gently sloping, and excessively drained and well drained. They are underlain by coarse sand and gravel at a depth of less than 36 inches. Permeability is moderately rapid or moderate in the upper part of the profile and very rapid in the coarse sand and gravel. The available water capacity is low or moderate. The depth to the water table is more than 5 feet.

This soil association is described in the following paragraphs.

*14. **Fordville-Renshaw association***

Nearly level to gently sloping, well drained and excessively drained, medium-textured soils formed in loamy alluvium

This soil association is a series of narrow beach ridges on the lake plain. It is nearly level and gently sloping.

This association makes up less than 1 percent of the survey area. It is about 28 percent Fordville soils, 17 percent Renshaw soils, and 55 percent soils of minor extent.

Fordville soils are on beach ridges, are nearly level to gently sloping, and are well drained. Their surface layer typically is black loam about 9 inches thick. The subsoil is very dark grayish-brown loam about 15 inches thick. Below this is coarse sand and gravel.

Renshaw soils are nearly level to gently sloping and are somewhat excessively drained. Their surface layer typically is black loam about 11 inches thick. The subsoil is dark-brown loam about 7 inches thick. The underlying material is coarse sand and gravel.

Less extensive in this association are the Antler, Gilby, Borup, Colvin, Tonka, Arvilla, and Sioux soils. The low, level interbeach areas are occupied by the somewhat poorly drained Antler and Gilby soils, the poorly drained, calcareous Borup and Colvin soils, and the poorly drained, noncalcareous Tonka soils. Some low beach ridges in the association are occupied by the somewhat excessively drained Arvilla and the excessively drained Sioux soils.

Corn, soybeans, small grain, and alfalfa grow fairly well on this association. Fertility is medium in the Fordville soils and low in the Renshaw soils. The organic-matter content is high in the Fordville soils and moderate in the Renshaw soils. The available water capacity is low in the Renshaw soils and low or moderate in the Fordville soils.

The main concerns of management are maintaining the level of fertility, conserving water, and preventing soil blowing. Nearly all of this association is used for cultivated crops. The main enterprise is growing cash crops.

Descriptions of the Soils

This section describes the soil series and mapping units in the survey area. Each soil series is described in considerable detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of

soils. Color terms are for moist soil unless otherwise stated. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit differs from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Marsh and Wet alluvial land, for example, do not belong to a soil series, but nevertheless, are listed in alphabetic order along with the soil series. The names of some soils are unlike those appearing in recently published surveys in adjacent counties. This is a result of change in concepts of soil series in the application of the current soil classification system.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and windbreak suitability group in which the mapping unit has been placed. The page for the description of each capability unit and the page for the description of each range site can be found by referring to the "Guide To Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the "Glossary" at the end of this survey. More detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*5*).[2]

[2] Italic numbers in parentheses refer to Literature Cited, p. 139.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Richland County	Ransom County Area	Total	Percent of survey area
	Acres	*Acres*	*Acres*	
Aastad-Forman loams	28,778		28,778	2.7
Aberdeen fine sandy loam	919		919	.1
Aberdeen silt loam	3,462		3,462	.3
Aberdeen-Galchutt silty clay loams	3,668		3,668	.4
Aberdeen-Ryan silty clay loams	5,249		5,249	.5
Antler silty clay loam	6,665		6,665	.7
Antler-Tonka silty clay loams	26,623		26,623	2.7
Arveson-Fossum fine sandy loams	6,117	126	6,243	.6
Arveson and Fossum loams	27,261	8,660	35,921	3.6
Arveson and Fossum loams, very wet	3,149	2,081	5,230	.5
Arvilla fine sandy loam	1,022		1,022	.1
Barnes-Buse loams, hilly	1,409		1,409	.1
Barnes-Buse loams, hilly, eroded	2,909		2,909	.3
Barnes-Buse-Langhei loams, hilly	5,500		5,500	.5
Barnes-Svea loams, undulating	479		479	(¹)
Bearden silty clay loam	10,590		10,590	1.1
Bearden and Glyndon silt loams, moderately deep over clay	12,116		12,116	1.2
Borup loam	16,474	444	16,918	1.7
Borup silt loam, very wet	2,292	87	2,379	.2
Cashel silty clay	750		750	.1
Colvin silty clay loam	2,076	108	2,184	.2
Dickey-Towner fine sandy loams, undulating	712	30	742	.1
Doran clay loam	11,489		11,489	1.1
Doran-Perella clay loams	1,034		1,034	.1
Doran-Tonka silty clay loams	1,731		1,731	.2
Dovray silty clay	1,830		1,830	.2
Eckman-Zell silt loams, rolling	1,522	4	1,526	.2
Egeland and Maddock fine sandy loams, undulating	1,601	114	1,715	.2
Embden-Tiffany fine sandy loams	57,741	52	57,795	5.8
Embden-Tiffany loams	14,091		14,091	1.4
Exline and Ryan soils	1,595		1,595	.2
Fairdale silt loam	546	104	650	.1
Fairdale silt loam, channeled	2,270	2,430	4,700	.5
Fairdale silty clay loam	451	20	471	(¹)
Fargo silty clay loam	15,279		15,279	1.5
Fargo silty clay	66,653		66,653	6.6
Fargo silty clay, depressional	6,117		6,117	.6
Fargo silty clay, gently sloping	3,087		3,087	.3
Fargo silty clay, till substratum	6,995		6,995	.7
Fargo-Enloe silty clay loams	17,064		17,064	1.7
Fargo-Enloe complex, till substratum	597		597	.1
Fargo-Hegne silty clays	8,161	46	8,207	.8
Fargo-Hegne silty clays, till substratum	3,602		3,602	.4
Fargo-Ryan silty clay loams	2,097		2,097	.2
Fargo-Ryan silty clays	14,954		14,954	1.5
Fordville-Renshaw loams	2,197	317	2,514	.2
Forman-Aastad loams, undulating	36,042		36,042	3.6

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Richland County	Ransom County Area	Total	Percent of survey area
	Acres	*Acres*	*Acres*	
Forman-Aastad loams, undulating, eroded	2,114		2,114	0.2
Forman-Buse loams, rolling	11,278		11,278	1.1
Forman-Buse loams, rolling, eroded	5,312		5,312	.5
Forman-Peever clay loams, undulating	1,550		1,550	.2
Fossum fine sandy loam	3,643	20	3,663	.4
Galchutt silt loam	7,626		7,626	.8
Galchutt-Enloe-Fargo complex	4,966		4,966	.5
Galchutt-Overly silt loams	26,239	48	26,287	2.6
Gardena silt loam	37,956	48	38,004	3.8
Gardena-Eckman silt loams, undulating	4,117		4,117	.4
Gardena and Embden loams	1,761	292	2,053	.2
Gilby silt loam	2,634		2,634	.3
Gilby silt loam, moderately saline	425		425	([1])
Gilby and Hamerly loams	1,894		1,894	.2
Glyndon silt loam	33,809	322	34,131	3.4
Glyndon-Tiffany very fine sandy loams	10,587	98	10,685	1.1
Glyndon-Tiffany loams, moderately deep over clay	665		665	.1
Glyndon and Wyndmere loams	15,062	269	15,331	1.5
Grano clay	816		816	.1
Hamar loamy fine sand	4,265	773	5,038	.5
Hamar loamy fine sand, moderately deep over clay	847		847	.1
Hamar fine sandy loam	3,277	273	3,550	.4
Hamar fine sandy loam, moderately deep over clay	858		858	.1
Hamar-Ulen loamy fine sands	710		710	.1
Hamar-Ulen fine sandy loams	2,242		2,242	.2
Hamerly loam	8,866		8,866	.9
Hecla loamy fine sand, loamy substratum	599		599	.1
Hecla-Hamar loamy fine sands	35,004	3,213	38,217	3.8
Hecla-Hamar loamy fine sands, severely eroded	941	241	1,182	.1
Hecla-Hamar fine sandy loams	15,035	720	15,755	1.6
Hecla-Hamar-Arveson complex	18,724	4,175	22,899	2.3
Hecla-Maddock loamy sands	396	6,642	7,038	.7
Hecla-Maddock sandy loams		2,405	2,405	.2
Kratka fine sandy loam	695	33	728	.1
LaDelle silty clay loam	3,735	732	4,467	.4
LaDelle and Wahpeton soils, channeled	3,433	88	3,521	.3
Lamoure silty clay loam	3,086	88	3,174	.3
LaPrairie silt loam	1,724	164	1,888	.2
Maddock loamy fine sand, rolling	444	174	618	.1
Maddock-Hecla loamy fine sands, undulating	7,309	5,180	12,489	1.2
Maddock-Hecla-Hamar loamy fine sands, undulating	11,251	6,109	17,360	1.7
Marsh	7,540	78	7,618	.8
Nutley silty clay, rolling	559		559	.1
Overly silty clay loam	16,447		16,447	1.6
Overly-Bearden silt loams, moderately saline	3,220		3,220	.3
Overly-Bearden silty clay loams, moderately saline	1,890		1,890	.2
Overly-Beotia silty clay loams, undulating	738		738	.1
Parnell silty clay loam	3,872		3,872	.4
Parnell and Tonka silty clay loams	2,460		2,460	.2
Peat		222	222	([1])
Peever-Forman clay loams	2,683		2,683	.3
Perella loam, moderately deep over clay	2,928		2,928	.3
Perella silty clay loam, moderately deep over clay	3,396		3,396	.3
Roliss clay loam	823		823	.1
Ryan-Fargo complex	26,664		26,664	2.7
Serden loamy fine sand	23,001	14,011	37,012	3.7
Serden-Stabilized dune land complex	12,269	12,745	25,014	2.5
Sioux-Renshaw complex, undulating	455		455	([1])
Sioux-Renshaw complex, hilly	368		368	([1])
Stirum-Arveson loams	3,066	46	3,112	.3
Strongly saline land	61		61	([1])
Svea loam	4,354		4,354	.4
Svea-Buse loams, undulating	1,227		1,227	.1
Svea-Buse loams, rolling	719		719	.1
Svea-Gardena loams	8,681		8,681	.9
Swenoda-Wyndmere fine sandy loams	2,904		2,904	.3
Tiffany fine sandy loam	5,108	84	5,192	.5
Tiffany loam	5,598	8	5,606	.6
Tiffany loam, moderately deep over clay	2,520		2,520	.2
Tonka silt loam	1,363		1,363	.1
Towner loamy fine sand	4,863	193	5,056	.5

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Richland County	Ransom County Area	Total	Percent of survey area
	Acres	*Acres*	*Acres*	
Towner and Swenoda fine sandy loams	7,415	231	7,646	0.8
Ulen fine sandy loam	2,907	102	3,009	.3
Vallers clay loam	1,358		1,358	.1
Venlo fine sandy loam	2,528	1,709	4,237	.4
Wahpeton silty clay	2,157	130	2,287	.2
Wet alluvial land	1,148	654	1,802	.2
Wyndmere fine sandy loam	13,266	128	13,394	1.3
Zell-Eckman silt loams, hilly	693	8	701	.1
Zell-Eckman silt loams, steep	1,028	98	1,126	.1
Water	2,284		2,284	.2
Total	927,424	77,177	1,004,601	100.0

[1] Less than 0.05 percent.

Aastad Series

The Aastad series consists of deep, moderately well drained, nearly level to gently undulating soils on glacial till plains. These soils formed in calcareous, medium and moderately fine textured glacial till.

In a representative profile (fig. 5) the surface layer is black loam about 12 inches thick. The subsoil is firm clay loam about 15 inches thick. The upper part is very dark grayish brown, and the lower part is olive brown. The underlying material is mixed light olive-brown and grayish-brown, calcareous clay loam mottled in the lower part with yellowish brown.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. Fertility and organic-matter content are high. Runoff is slow to medium.

Aastad soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Aastad loam from an area of Aastad-Forman loams in a cultivated field, 165 feet west and 1,000 feet south of the northeast corner of sec. 5, T. 131 N., R. 51 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; moderate, medium and fine, granular structure; friable, slightly sticky, slightly plastic; slightly acid; abrupt, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky structure; friable, slightly sticky, slightly plastic; neutral; clear, wavy boundary.

B21—12 to 19 inches, very dark grayish-brown (2.5Y 3/2) clay loam; dark grayish brown (2.5Y 4/2) when dry; moderate, medium, prismatic structure parting to strong, medium, subangular blocky; firm, sticky, plastic; thin, continuous clay films on all faces of peds; neutral; gradual, irregular boundary.

B22—19 to 27 inches, olive-brown (2.5Y 4/3) clay loam; light brownish gray (2.5Y 6/2) when dry; moderate, medium, prismatic structure parting to strong, medium, subangular blocky; firm, sticky, plastic; thin patchy clay films on all faces of peds; neutral; slight effervescence; gradual, irregular boundary.

C1ca—27 to 37 inches, light olive-brown (2.5Y 5/3) clay loam; light gray (2.5Y 7/2) when dry; weak, coarse, subangular blocky structure parting to weak, fine, subangular blocky; firm, sticky, plastic; mildly

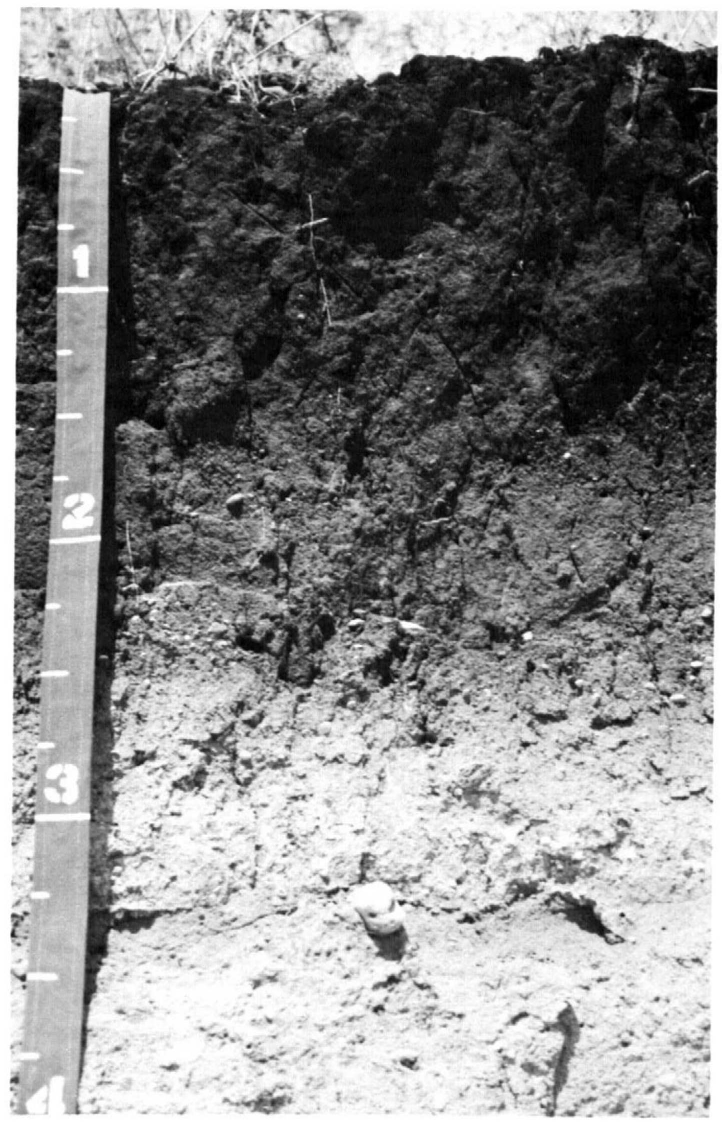

Figure 5.—**Profile of Aastad loam showing thick surface layer.**

alkaline; violent effervescence; common masses of segregated lime; gradual, irregular boundary.

C2—37 to 60 inches, light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) clay loam; light yellowish brown (2.5Y 6/3) and light gray (2.5Y 7/2) when dry; few, fine, distinct, yellowish-brown (10YR 5/8) mottles; massive; firm, sticky, plastic; mildly alkaline; strong effervescence.

The solum ranges from 18 to 30 inches in thickness. The A horizon is loam or silt loam and is 8 to 16 inches thick. The B horizon is very dark brown, very dark grayish brown, dark grayish brown, or olive brown. The C horizon is loam or clay loam. The depth to the lime zone ranges from 18 to 30 inches.

Aastad soils are associated with Forman soils, and they formed in the same kind of material as Svea soils. They are dark colored to a greater depth than Forman soils and are not so well drained. They contain more clay in the B horizon than Svea soils.

Aastad-Forman loams (0 to 3 percent slopes) (Af).—This mapping unit is on the glacial till plain. It is about 60 percent Aastad loam and 40 percent Forman loam. Aastad loam is on concave and plane lower slopes, and Forman loam is on the slightly higher convex slopes. The Aastad soil has the profile described as representative of the series. Included in mapping were a few small areas of Parnell, Tonka, and Hamerly soils.

Aastad loam is moderately well drained, and Forman loam is well drained. Runoff is slow. Permeability is moderate in the upper part of the soil and moderately slow in the underlying material. The available water capacity is high.

Most areas are used for crops. The soils are well suited to farming. Conserving water and maintaining the level of fertility are the main management needs. Capability unit IIc-6. Aastad soil in Overflow range site and windbreak suitability group 1, Forman soil in Silty range site and windbreak suitability group 3.

Aberdeen Series

The Aberdeen series consists of deep, somewhat poorly drained, nearly level soils that have a claypan. These soils are on plane and concave surfaces on the lake plain. They formed in medium to fine-textured lacustrine sediments.

In a representative profile the surface layer is black silty clay loam about 9 inches thick. The subsurface layer is very dark gray silt loam about 2 inches thick. The subsoil is firm clay about 15 inches thick. The upper part is very dark brown, and the lower part is very dark grayish brown. The underlying material is dark grayish-brown and olive-gray silty clay that contains crystals of gypsum and other salts.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. Root development is inhibited to some extent by the claypan subsoil and the salinity of the underlying material. Runoff is slow.

Aberdeen soils are suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas are used for crops.

Representative profile of Aberdeen silty clay loam from an area of Aberdeen-Galchutt silty clay loams in a cultivated field, 2,565 feet south and 365 feet west of the northeast corner of sec. 23, T. 134 N., R. 49 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; moderate, fine and medium, granular structure; friable, sticky, plastic; slightly acid; abrupt, smooth boundary.

A2—9 to 11 inches, very dark gray (10 YR 3/1) silt loam; gray (10YR 5/1) when dry; weak, thin, platy structure; very friable, slightly sticky, slightly plastic; slightly acid; abrupt, wavy boundary.

B21t—11 to 19 inches, very dark brown (10YR 2/2) clay; dark gray (10YR 4/1) when dry; very dark gray (10YR 3/1) silt coatings on faces of peds; moderate medium and coarse, columnar structure parting to strong, fine, angular blocky structure; very firm, very sticky, very plastic; mildly alkaline; gradual, wavy boundary.

B22t—19 to 26 inches, very dark grayish-brown (2.5Y 3/2) clay; grayish brown (2.5Y 5/2) when dry; moderate, medium and coarse, prismatic structure parting to strong, fine, angular blocky; very firm, very sticky, very plastic; mildly alkaline; clear, wavy boundary.

C1ca—26 to 36 inches, dark grayish-brown (2.5Y 4/2) silty clay; light brownish gray (2.5Y 6/2) when dry; strong, very fine, angular blocky structure; firm, very sticky, very plastic; moderately alkaline; violent effervescence; few fine crystals of gypsum and other salts; gradual, wavy boundary.

C2—36 to 60 inches, olive-gray (5Y 5/2) silty clay; light olive gray (5Y 6/2) when dry; massive; firm, very plastic; mildly alkaline; strong effervescence; few fine crystals of gypsum.

The solum ranges from 20 to 34 inches in thickness. The A1 horizon is silty clay loam, silt loam, or fine sandy loam and is 6 to 10 inches thick. The A2 horizon is 1 to 4 inches thick. In a few places plowing has mixed the Ap and A2 horizons. The B horizon is black, very dark brown, very dark gray, or very dark grayish brown and is heavy silty clay loam, silty clay, or clay. Crystals of gypsum and other salts are in the lower part of the B horizon and in the C horizon. The C horizon ranges from silt loam to clay.

Aberdeen soils are associated with Galchutt and Ryan soils. They have thinner A1 and A2 horizons than Galchutt soils and more sodium and magnesium in the B and C horizons. They have a thicker A1 horizon than Ryan soils and are deeper over salts.

Aberdeen fine sandy loam (0 to 1 percent slopes) (Ag).—This soil is on the lake plain. It has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam.

This soil is somewhat poorly drained. Runoff is slow. Permeability is moderately rapid in the surface layer and slow in the subsoil and underlying material. The available water capacity is high. The claypan subsoil restricts root growth and downward movement of water. The hazard of soil blowing is severe in cultivated areas.

This soil is suited to farming, and most areas are used for crops. The main concerns in management are conserving water, preventing soil blowing, and maintaining the level of fertility. Capability unit IIIe-3P; Silty range site; windbreak suitability group 4.

Aberdeen silt loam (0 to 1 percent slopes) (Ah).—This soil is on the lake plain. It has a profile similar to that described as representative of the series, but the surface layer is silt loam. Included in mapping are small areas of Galchutt soils.

This Aberdeen soil is somewhat poorly drained. Runoff is slow. Permeability is slow, and the available water capacity is high. The claypan subsoil restricts root growth and downward penetration of water.

This soil is suited to farming, and most areas are used for crops. The main concerns in management are

conserving water and maintaining the level of fertility. Capability unit IIIs-P6; Clayey range site; windbreak suitability group 4.

Aberdeen-Galchutt silty clay loams (0 to 1 percent slopes) (Ak).—This mapping unit is on the lake plain. It is about 55 percent Aberdeen silty clay loam and 45 percent Galchutt silty clay loam. The Aberdeen soil has the profile described as representative of the series. The Galchutt soil has a profile similar to that described as representative of its series, but the surface layer is silty clay loam. Included in mapping are small areas of Fargo, Enloe, and Overly soils.

The Aberdeen and Galchutt soils are somewhat poorly drained. Permeability is slow, and the available water capacity is high. Runoff is slow. The claypan subsoil in the Aberdeen soil restricts root growth and downward movement of water.

These soils are suited to farming, and nearly all the acreage is used for cultivated crops. Maintaining the level of fertility and removing excess water during periods of high rainfall are the main management needs. Capability unit IIIs-P6. Aberdeen soil in Clayey range site and windbreak suitability group 4, Galchutt soil in Silty range site and windbreak suitability group 1.

Aberdeen-Ryan silty clay loams (0 to 1 percent slopes) (Ao).—This mapping unit is on plane and slightly concave surfaces on the lake plain. It is about 70 percent Aberdeen silty clay loam, 20 percent Ryan silty clay loam, and 10 percent Fargo silty clay loam.

The Aberdeen and Ryan soils have a claypan subsoil that restricts root growth and downward movement of water. In the Aberdeen soil the pan is below plow depth, but in the Ryan soil it is within a depth of 5 inches. In some places the subsoil of the Ryan soil has been mixed with the surface layer in plowing. Where this occurs, the surface layer is very sticky when wet and hard and cloddy when dry and is difficult to keep in good tilth.

Runoff is very slow. The available water capacity is high in the Aberdeen soil, but low in the Ryan soil because the salt content is high.

These soils are suited to farming, and nearly all the acreage is in crops. Maintaining tilth and fertility and removing excess water during periods of high rainfall are the chief management needs. Capability unit IIIs-P4. Aberdeen soil in Clayey range site and windbreak suitability group 4, Ryan soil in Thin Claypan range site and windbreak suitability group 9.

Antler Series

The Antler series consists of deep, somewhat poorly drained, nearly level soils on the lake plain. These soils are plane, concave, and slightly convex. They have a zone of lime accumulation within 16 inches of the surface. They formed in moderately fine textured lacustrine sediments and the underlying clay loam glacial till.

In a representative profile the surface layer is black silty clay loam about 10 inches thick. The underlying material, to a depth of about 16 inches, is dark-gray strongly calcareous silty clay loam. The next layer is grayish-brown clay loam about 18 inches thick. Below this is light olive-brown clay loam mottled with olive gray and strong brown.

Permeability is moderately slow in the upper part of the profile and slow in the underlying glacial till. The available water capacity is high. Organic-matter content and fertility are high. Runoff is slow. The water table is within 1 to 4 feet of the surface early in spring and during periods of heavy rainfall.

Antler soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Antler silty clay loam in an area of Antler-Tonka silty clay loams in a cultivated field, 150 feet east and 1,990 feet south of the northwest corner of sec. 17, T. 130 N., R. 47 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to moderate, fine, granular; friable, sticky and plastic; mildly alkaline; slight effervescence; abrupt, smooth boundary.

Aca—6 to 10 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; common, medium, distinct, gray (10YR 6/1) lime spots; weak, coarse, subangular blocky structure parting to moderate, fine, granular; friable, sticky and plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

Cca—10 to 16 inches, dark-gray (5Y 4/1) silty clay loam; gray (5Y 6/1) when dry; weak; medium, subangular blocky structure; friable, sticky and plastic; mildly alkaline; violent effervescence; clear, wavy boundary.

CCs—16 to 34 inches; grayish-brown (2.5Y 5/2) clay loam; light brownish gray (2.5Y 6/2) when dry; weak, coarse and medium, subangular blocky structure; friable, sticky and plastic; mildly alkaline; strong effervescence; common gypsum crystals; gradual, wavy boundary.

IIC1—34 to 60 inches, light olive-brown (2.5Y 5/4) clay loam; light yellowish brown (2.5Y 6/3) when dry; common, medium, distinct, olive-gray (5Y 5/2) and common, fine and medium, distinct, strong-brown (7.5YR 5/8) mottles; massive; firm, sticky and plastic; moderately alkaline; strong effervescence; few gypsum crystals.

The A horizon is silty clay loam or clay loam 6 to 16 inches thick. Depth to the zone of lime accumulation ranges from 6 to 16 inches. The Cca horizon is dark-gray or gray silty clay loam or clay loam. The depth to the firm clay loam glacial till IIC horizon ranges from 20 to 36 inches. Mottles of gray, yellowish brown, reddish brown, and brown are in this horizon.

Antler soils are associated with Tonka soils, and they are similar to Gilby soils. They differ from Tonka soils in having a zone of lime accumulation within a depth of 16 inches. They have more clay in the upper part of the profile than Gilby soils.

Antler silty clay loam (0 to 3 percent slopes) (Ar).—This soil is on the lake plain. Included in mapping are small areas of Doran, Perella, and Tonka soils.

Runoff is slow. Permeability is moderately slow, and the available water capacity is high. The water table is within 1 to 3 feet of the surface in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard in cultivated areas.

This soil is suited to farming, and most areas are used for crops. The main concerns in management are preventing soil blowing and maintaining the level of fertility. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Antler-Tonka silty clay loams (0 to 3 percent slopes) (As).—This mapping unit is on the lake plain. It is about 60 percent Antler silty clay loam, 30 percent Tonka silty clay loam, and 10 percent small areas of Doran and Perella soils. The Antler soil is plane and slightly convex, and the Tonka soil is in shallow depressions.

The Antler soil in this mapping unit has the profile described as representative of the series. The Tonka soil has a profile similar to that described as representative of the Tonka series, but the surface layer is silty clay loam.

Runoff is slow, and the Tonka soil is frequently ponded. The available water capacity is high in both soils. The Antler soil is moderately susceptible to soil blowing.

The soils in this mapping unit are suited to farming, and most areas are used for cultivated crops. The main concerns of management are maintaining fertility, preventing soil blowing, and removing excess water during periods of heavy rain. Capability unit IIe-4L. Antler soil in Silty range site and windbreak suitability group 1, Tonka soil in Wet Meadow range site and windbreak suitability group 2.

Arveson Series

The Arveson series consists of deep, poorly drained and very poorly drained, nearly level soils on the lake plain and the Sheyenne Delta. These soils have a zone of lime accumulation within 16 inches of the surface. They are on flats and in shallow depressions. They formed in moderately coarse and coarse textured lacustrine sediments.

In a representative profile the surface layer is black fine sandy loam about 10 inches thick. The underlying material, to a depth of about 20 inches, is dark-gray, strongly calcareous fine sandy loam. Below this is olive-gray loamy fine sand mottled with very dark brown and yellowish brown.

Permeability is moderately rapid, and the available water capacity is moderate. Organic-matter content is high, and fertility is medium. Runoff is very slow. The water table is within 1 to 3 feet of the surface for extended periods during the growing season, and these soils are occasionally ponded.

Arveson soils are well suited to hay and pasture. If excess water is removed, they are suited to cultivated crops. Limitations for many nonfarm uses are severe. Most areas of these soils are used for hay and pasture. Some areas are used for cultivated crops.

Representative profile of Arveson fine sandy loam in an area of Arveson-Fossum fine sandy loams in a cultivated field, 1,550 feet south and 120 feet east of the northwest corner of sec. 29, T. 130 N., R. 49 W.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) when dry; weak, medium, granular structure; very friable; mildly alkaline; slight effervescence; clear, wavy boundary.

C1ca—10 to 20 inches; dark-gray (2.5Y 4/1) fine sandy loam; gray (2.5Y 6/1) when dry; weak, medium and fine, subangular blocky structure; very friable; moderately alkaline; violent effervescence; clear, wavy boundary.

C2g—20 to 32 inches, olive-gray (5Y 5/2) loamy fine sand; light gray when dry; common, medium, prominent, very dark brown (10YR 2/2) mottles; weak, medium, subangular blocky structure; very friable; moderately alkaline; strong effervescence; gradual, wavy boundary.

C3g—32 to 60 inches, olive-gray (5Y 5/2) loamy fine sand; light gray (5Y 7/2) when dry; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is black or very dark gray fine sandy loam or loam 8 to 15 inches thick. The Cca horizon is fine sandy loam or loam. The Cg horizon is fine sand, loamy fine sand, or fine sandy loam to a depth of about 40 inches. Below a depth of 40 inches it ranges from fine sand to silty clay.

Arveson soils formed in the same kind of material as the closely associated Fossum, Hamar, Hecla, and Stirum soils. They contain more calcium carbonate in the upper part of the C horizon than Fossum, Hamar, and Hecla soils, and they are more poorly drained than Hecla soils. They contain more calcium carbonate and less exchangeable sodium than Stirum soils.

Arveson-Fossum fine sandy loams (0 to 1 percent slopes) (At).—This mapping unit consists of poorly drained soils on flats and in shallow depressions in the Sheyenne Delta and the lake plain. It is about 65 percent Arveson fine sandy loam and about 35 percent Fossum loam. Included in mapping are small areas of Hecla, Hamar, and Ulen soils.

The Arveson soil has the profile described as representative of the series. The Fossum soil has a profile similar to that described as representative of the Fossum series, but the surface layer is fine sandy loam.

Runoff is slow, and the water table is at or near the surface in spring and during periods of heavy rain. If the surface layer is bare and dry, these soils are susceptible to soil blowing.

Some areas of these soils are used for cultivated crops, but most are used for native hay or pasture (fig. 6). The soils are suited to farming, but excess water is a limitation. The main concerns of management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIIwe-3; Wet Meadow range site; windbreak suitability group 2.

Arveson and Fossum loams (0 to 1 percent slopes) (Au).—This mapping unit consists of two nearly level, poorly drained soils on broad flats and in shallow depressions on the Sheyenne Delta and the lake plain. Some areas are Arveson loam, some are Fossum loam, and some are both.

The Arveson soil has a profile similar to that described as representative of the series, but the surface layer is loam. The Fossum soil has the profile described as representative of the Fossum series.

Runoff is slow, and the water table is at or near the surface in the spring and during periods of heavy rain. If the surface layer is bare and dry, the soils are moderately susceptible to soil blowing.

Some areas of these soils are cultivated, but most areas are used for native hay and pasture. The soils are suited to farming, but excess water is a limitation. The main concerns of management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIw-4L; Wet Meadow range site; windbreak suitability group 2.

Arveson and Fossum loams, very wet (0 to 1 percent slopes) (Av).—This mapping unit consists of two, nearly

Figure 6.—Native hay on Arveson-Fossum fine sandy loams.

level, poorly drained and very poorly drained soils in shallow depressions on the Sheyenne Delta and the lake plain. Some areas are Arveson loam, some are Fossum loam, and some are both.

The Arveson soil has a profile similar to that described as representative of the series, but the surface layer is loam.

The Arveson and Fossum soils have a seasonal high water table at or near the surface during most of the growing season. They are frequently ponded. They are too wet for cultivated crops and are better suited to hay and pasture than to most other uses. The main concern of management is removing excess water, but outlets generally are not available. Capability unit Vw-WL; Wetland range site; windbreak suitability group 2.

Arvilla Series

The Arvilla series consists of shallow and moderately deep, somewhat excessively drained, nearly level to gently sloping soils on low beach ridges on the lake plain. These soils formed in moderately coarse textured alluvium underlain by sand and gravel.

In a representative profile the surface layer is black fine sandy loam about 9 inches thick. The subsoil is dark-brown, very friable coarse sandy loam 6 inches thick. The underlying material is dark grayish-brown coarse sand and gravel.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying sand and gravel. The available water capacity is low. Organic-matter content is moderate, and fertility is medium. Runoff is slow.

Arvilla soils are suitable for farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Arvilla fine sandy loam in a cultivated field, 240 feet west and 2,090 feet south of the northeast corner of sec. 28, T. 129 N., R. 48 W.

Ap—0 to 9 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak, fine, granular structure; very friable; neutral; abrupt, smooth boundary.

B2—9 to 15 inches, dark-brown (10YR 3/3) coarse sandy loam; dark brown (10YR 4/3) when dry; moderate, medium, prismatic structure; very friable; neutral; gradual, wavy boundary.

IIC1—15 to 40 inches, dark grayish-brown (10YR 4/2) coarse sand and gravel; light brownish gray (10YR 6/2) when dry; single grained; loose; mildly alkaline; slight effervescence; gradual, wavy boundary.

IIC2—40 to 60 inches, dark grayish-brown (10YR 4/2) coarse sand; light brownish gray (10YR 6/2) when dry; single grained; loose; mildly alkaline; slight effervescence.

Thickness of the solum and the depth to sand and gravel ranges from 14 to 25 inches. The A horizon is black or very dark gray sandy loam or fine sandy loam 6 to 12 inches thick. The B horizon is very dark grayish-brown, dark grayish-brown, or dark-brown coarse sandy loam, sandy loam, or light loam.

Arvilla soils formed in the same kind of material as Fordville, Renshaw, and Sioux soils. They have a sandier B horizon than Fordville and Renshaw soils. They are deeper over coarse sand and gravel than Sioux soils.

Arvilla fine sandy loam (0 to 6 percent slopes) (Aw).—This soil is on low, narrow beach ridges on the lake plain. Included in mapping are small areas of Maddock soils.

Runoff is slow, and the available water capacity is low. The hazard of soil blowing is severe.

This soil is suited to farming, and most areas are used for crops. The main concerns of management are conserving moisture, preventing soil blowing, and maintaining fertility. Capability unit IIIes-3; Shallow to Gravel range site; windbreak suitability group 6.

Barnes Series

The Barnes series consists of deep, well-drained, gently undulating to hilly soils on glacial till plains. These soils are plane or convex. They formed in calcareous glacial till of medium and moderately fine texture.

In a representative profile (fig. 7) the surface layer is black loam about 8 inches thick. The subsoil is dark grayish-brown loam about 12 inches thick. The underlying material, to a depth of about 30 inches, is grayish-brown loam. Below this is light olive-brown clay loam mottled with gray and yellowish brown.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. Organic-matter content is high, and fertility is high. Runoff is medium to rapid.

The milder slopes of Barnes soils are well suited to farming. Hilly Barnes soils are better suited to hay and pasture grasses than to cultivated crops. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops. Some steeper areas are used for hay and pasture.

Representative profile of Barnes loam in an area of Barnes-Svea loams, undulating, in a cultivated field, 185 feet west and 2,530 feet south of the northeast corner of sec. 17, T. 131 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to medium, fine, crumb; friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

B2—8 to 20 inches, dark grayish-brown (10YR 4/2) loam; brown (10YR 5/3) when dry; moderate, medium, prismatic structure parting to weak, medium, subangular blocky; friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

C1ca—20 to 30 inches, grayish-brown (2.5Y 5/2) loam; light brownish gray (2.5Y 6/2) when dry; weak, coarse and medium, prismatic structure parting to weak, medium, subangular blocky; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

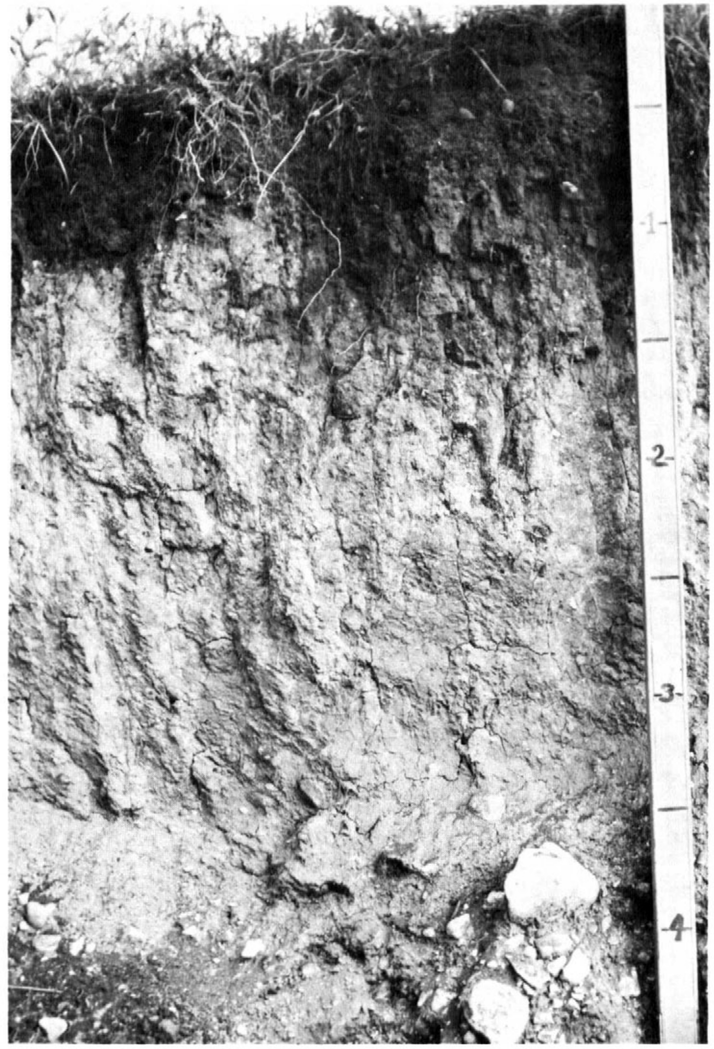

Figure 7.—Profile of Barnes loam.

C2—30 to 60 inches, light olive-brown (2.5Y 5/4) clay loam; light yellowish brown (2.5Y 6/4) when dry; few, fine, faint, gray (2.5Y 6/1) and yellowish-red (10YR 5/8) mottles; friable, sticky and slightly plastic; mildly alkaline; strong effervescence.

The solum ranges from 11 to 22 inches in thickness. The A horizon is black or very dark gray and is 5 to 9 inches thick. The B horizon is dark-brown, dark grayish-brown, or very dark grayish-brown loam or light clay loam. The C horizon is loam or clay loam. The depth to the zone of lime accumulation ranges from 11 to 22 inches.

Barnes soils are associated with Buse, Langhei, and Svea soils, and they formed in the same kind of material as Forman soils. They differ from Buse and Langhei soils in having a B horizon and a thicker solum. They are dark colored to a lesser depth and are better drained than Svea soils. They have less clay in the B horizon than Forman soils.

Barnes-Buse loams, hilly (9 to 12 percent slopes) (BbD).—This mapping unit consists of medium textured soils on the glacial-till plain. It is about 65 percent Barnes loam and about 35 percent Buse loam. Buse

loam is on the hilltops and upper parts of hillsides and Barnes loam is on the lower parts.

Runoff is rapid. The hazard of erosion is severe.

Most areas of these soils are used for crops, but some are in pasture and hay. The soils are suited to small grain and tame grasses, but they are poorly suited to row crops because the hazard of erosion is severe. The main concerns of management are controlling erosion, conserving water, and maintaining fertility. Capability unit IVe-6. Barnes soil in Silty range site and windbreak suitability group 3, Buse soil in Thin Upland range site and windbreak suitability group 8.

Barnes-Buse loams, hilly, eroded (9 to 12 percent slopes) (BbD2).—This mapping unit consists of medium-textured soils on the glacial till plain. It is about 65 percent Barnes loam and about 35 percent Buse loam. Buse loam is on the hilltops and upper parts of hillsides, and Barnes loam is on the lower parts.

The Barnes and Buse soils in this complex have profiles similar to those described as representative of their respective series, but part of the surface layer has been lost through erosion. In some of the more eroded spots the light-colored, calcareous underlying material of the Buse soil is exposed at the surface. In most of the acreage, tillage has mixed subsoil material with what remains of the surface layer.

Runoff is rapid on these soils. The hazard of further erosion is severe.

All the acreage has been cultivated, but some areas have been reseeded to permanent pasture. The soils are suited to small grain and tame grasses, but they are poorly suited to row crops because the hazard of erosion is severe. The main concerns of management are preventing erosion, conserving water, and maintaining fertility. Capability unit IVe-6. Barnes soil in Silty range site and windbreak suitability group 3, Buse soil in Thin Upland range site and windbreak suitability group 8.

Barnes-Buse-Langhei loams, hilly (12 to 20 percent slopes) (BcD).—This mapping unit consists of medium-textured soils on the steepest parts of the glacial till plain. It is about 40 percent Barnes loam, 35 percent Buse loam, and 25 percent Langhei loam. Langhei loam and Buse loam are on the hilltops and steep upper hillsides, and Barnes loam is on the lower parts of hillsides. Included in mapping are small areas of Aastad soils.

Barnes loam has a profile similar to that described as representative of the series, but the surface layer is a few inches thinner. Buse and Langhei loams have profiles described as representative of their respective series.

Runoff is very rapid. The hazard of erosion is very severe.

This complex is better suited to pasture than to most other uses. Most areas are in native grass and are used for grazing (fig. 8). The main concern of management is maintaining a permanent plant cover to control erosion and runoff and to provide high-quality forage for livestock. Capability unit VIe-TU. Barnes soil in Silty range site and windbreak suitability group 3, Buse and Langhei soils in Thin Upland range site and windbreak suitability group 8.

Barnes-Svea loams, undulating (3 to 6 percent slopes) (BdB).—This mapping unit consists of medium-textured soils on the glacial till plain. It is about 60 percent Barnes loam and about 40 percent Svea loam. Barnes loam is on the upper parts of convex surfaces, and Svea loam is on the lower parts of plane and concave surfaces. Included in mapping are small areas of Aastad, Forman, and Tonka soils.

The Barnes soil in this complex has the profile described as representative of the series.

Runoff is medium, and the hazard of erosion is moderate. Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. Available water capacity is high.

Barnes and Svea soils are well suited to farming and nearly all areas are used for cultivated crops. The main concerns of management are maintaining fertility, conserving water, and preventing erosion. Capability unit IIe-6; Silty range site. Barnes soil in windbreak suitability group 3, Svea soil in windbreak suitability group 1.

Bearden Series

The Bearden series consists of deep, somewhat poorly drained, nearly level soils on the lake plain. These soils have a zone of lime accumulation within 16 inches of the surface. They are plane or slightly convex. They formed in medium-textured or moderately fine textured lacustrine sediments.

In a representative profile (fig. 9) the surface layer is black silty clay loam about 10 inches thick. The underlying material, to a depth of 24 inches, is gray silty clay loam that contains a large amount of lime. Below this are alternating layers of light olive-brown silty clay loam and silt loam that are mottled yellowish brown in the lower part.

Permeability is moderately slow, and the available water capacity is high. Organic-matter content and fertility are high. Runoff is slow. Some of the Bearden soils are underlain by clay or silty clay at a depth of 30 to 50 inches. Permeability in these soils is moderately slow in the upper part and slow in the clayey substratum.

Bearden soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Bearden silty clay loam in a cultivated field, 150 feet north and 345 feet west of the southeast corner of sec. 35, T. 135 N., R. 49 W.

Ap—0 to 10 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when moist; weak, medium, subangular blocky structure parting to moderate, fine, granular; friable, slightly sticky and plastic; mildly alkaline; slight effervescence; abrupt, smooth boundary.

C1ca—10 to 24 inches, gray (10YR 5/1) silty clay loam; gray 10YR 6/1) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; clear, wavy boundary.

C2—24 to 38 inches, light olive-brown (2.5Y 5/3) silty clay loam; light brownish gray (2.5Y 6/2) when dry; weak, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

Figure 8.—**Native grass in an area of Barnes-Buse-Langhei loams, hilly. These soils are not suitable for cultivation. Most areas are used for grazing.**

C3—38 to 46 inches, light olive-brown (2.5Y 5/4) silt loam; light yellowish brown (2.5Y 6/3) when dry; massive; friable, slightly sticky and slightly plastic; moderately alkaline; clear, smooth boundary.

C4—46 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam; light yellowish brown (2.5Y 6/3) when dry; common, fine and medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; friable, sticky and plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray silt loam or silty clay loam 6 to 16 inches thick. The upper boundary of the Cca horizon is within 16 inches of the surface. In some places there is a IIC horizon of clay or silty clay below a depth of 30 inches.

Bearden soils formed in the same kind of material as Overly and Colvin soils, and they are associated with Glyndon soils. They have a lime zone at a lesser depth and are more poorly drained than Overly soils. They are better drained than Colvin soils. They contain more clay in the upper part of the C horizon than Glyndon soils.

Bearden silty clay loam (0 to 1 percent slopes) (Bf).—This plane and slightly concave soil is on the lake plain. Areas are medium to large and irregularly shaped. This soil has the profile described as representative of the series. Included in mapping are small areas of moderately well drained Overly soils and poorly drained Colvin and Perella soils.

Runoff is slow. The hazard of soil blowing is moderate. Permeability is moderately slow, and the available water capacity is high.

This soil is well suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility, conserving moisture, and preventing soil blowing. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Bearden and Glyndon silt loams, moderately deep over clay (0 to 3 percent slopes) (Bg).—This mapping unit is on plane and slightly convex surfaces on the lake plain. Some areas are Bearden silt loam, moderately deep over clay, some are Glyndon silt loam, moderately deep over clay, and some are both.

The Bearden soil has a profile similar to that described as representative of the series, but the surface layer is silt loam and the underlying material below a depth of about 30 inches is silty clay or clay. The Glyndon soil has a profile similar to that described as representative of the Glyndon series, but the underlying material below a depth of about 36 inches is silty clay or clay.

These soils are somewhat poorly drained. Runoff is slow. Permeability in the Bearden soil is moderately

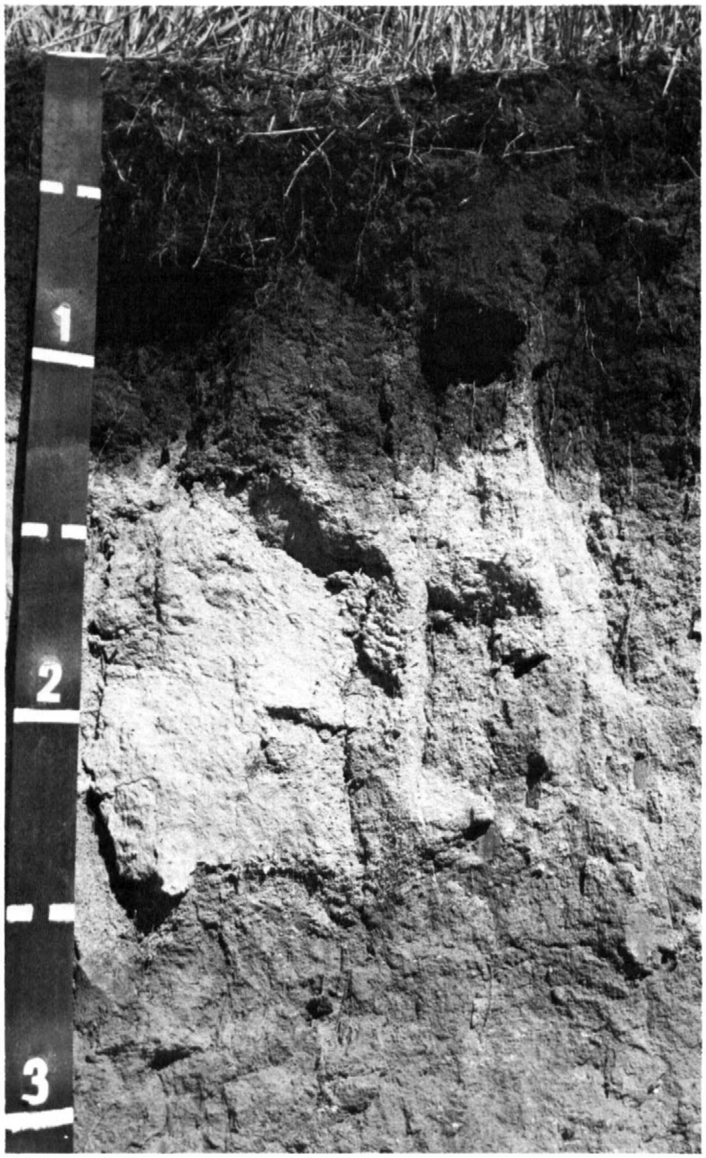

Figure 9.—**Profile of Bearden silty clay loam showing black surface layer and gray lime zone.**

slow above the clay substratum and slow below. Permeability in the Glyndon soil is moderate above the clay substratum and slow below. The soils are moderately susceptible to soil blowing.

These soils are well suited to farming, and most areas are used for cultivated crops. The main concerns of management are maintaining fertility, conserving moisture, and preventing soil blowing. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Beotia Series

The Beotia series consists of deep, well-drained, gently undulating soils on the lake plain. These soils are plane or convex. They formed in moderately fine textured lacustrine sediments.

In a representative profile the surface layer is black silty clay loam about 9 inches thick. The subsoil is friable silty clay loam about 11 inches thick. The upper part is very dark grayish brown, and the lower part is dark grayish brown. The underlying material is light olive-brown, calcareous silty clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is medium.

Beotia soils are well suited to farming. Limitations for many nonfarm uses are slight to moderate. Most areas of these soils are used for crops.

The Beotia soils in this survey area are mapped only with Overly soils.

Representative profile of Beotia silty clay loam in an area of Overly-Beotia silty clay loams, undulating, in a cultivated field, 300 feet south and 650 feet east of the northwest corner of sec. 26, T. 131 N., R. 50 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; moderate, fine and medium, granular structure; friable, sticky and plastic; neutral; abrupt, smooth boundary.

B21—9 to 16 inches, very dark grayish-brown (10YR 3/2) silty clay loam; dark grayish brown (10YR 4/2) when dry; moderate, medium, prismatic structure parting to moderate, medium and coarse, subangular blocky; friable, sticky and plastic; neutral; clear, wavy boundary.

B22—16 to 20 inches, dark grayish-brown (10YR 4/2) silty clay loam; grayish brown (10YR 5/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; friable, sticky and plastic; neutral; clear, wavy boundary.

C1ca—20 to 34 inches, light olive-brown (2.5Y 5/4) silty clay loam; pale yellow (2.5Y 7/3) when dry; weak, coarse, subangular blocky structure; friable, sticky and plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2—34 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam; pale yellow (2.5Y 7/3) when dry; few, fine, distinct, yellowish-brown (10YR 5/8) mottles; massive; friable, sticky and plastic; mildly alkaline; strong effervescence.

The solum ranges from 16 to 30 inches in thickness. The A horizon is very dark gray or black and is 7 to 12 inches thick. The B horizon is very dark brown, dark brown, very dark grayish brown or dark grayish brown and is 9 to 18 inches thick. The depth to the Cca horizon ranges from 16 to 30 inches. In some places the C horizon is silty clay below a depth of 40 inches.

Beotia soils are associated with Overly soils. They are better drained than Overly soils.

Borup Series

The Borup series consists of deep, poorly drained, nearly level soils in depressions and on flats on the lake plain and the Sheyenne Delta. These soils have a zone of lime accumulation within 16 inches of the surface. They formed in coarse and medium-textured lacustrine sediments.

In a representative profile the surface layer is loam about 13 inches thick. The upper 8 inches is black, and the lower 5 inches is very dark gray. The underlying material, to a depth of 20 inches, is dark-gray silt loam that contains a large amount of lime. Below this is olive and light olive-gray very fine sandy loam mottled with yellowish brown.

Permeability is moderate in the upper part of the profile and moderately rapid in the underlying material.

The available water capacity is high. The organic-matter content is high, and fertility is medium. Runoff is slow. The water table is within 1 to 3 feet of the surface early in spring and in wet seasons, and the soils are occasionally ponded.

Borup soils are suited to farming if excess water is removed. They are well suited to pasture and hay. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some areas are in native grass, hay, and pasture.

Representative profile of Borup loam in a cultivated field, 2,350 feet west and 105 feet north of the southeast corner of sec. 4, T. 132 N., R. 50 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; moderate, fine, granular structure; friable, slightly sticky and slightly plastic; mildly alkaline; slight effervescence; abrupt, smooth boundary.

A1ca—8 to 13 inches, very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure; friable; slightly sticky and slightly plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

C1ca—13 to 20 inches, dark-gray (2.5Y 4/1) silty loam; gray (2.5Y 5/1) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; clear, wavy boundary.

C2cag—20 to 28 inches, olive (5Y 5/3) very fine sandy loam; pale yellow (5Y 7/3) when dry; few, fine, distinct, very dark brown (10YR 2/2) mottles; weak, fine, subangular blocky structure; very friable; mildly alkaline; strong effervescence; gradual, wavy boundary.

C3g—28 to 42 inches, olive (5Y 5/3) very fine sandy loam; pale yellow (5Y 7/3) when dry; common, medium, prominent, yellowish-brown (10YR 5/8) mottles; massive; very friable; mildly alkaline; slight effervescence; gradual, wavy boundary.

C4g—42 to 60 inches, light olive-gray (5Y 6/2) very fine sandy loam; light gray (5Y 7/2) when dry; many, coarse, prominent, yellowish-brown (10YR 5/8) mottles; massive; very friable; mildly alkaline; slight effervescence.

The A horizon is black or very dark gray loam or silt loam 6 to 14 inches thick. Depth to the zone of lime accumulation ranges from 6 to 14 inches. The C horizon is silt loam, very fine sandy loam, or loamy very fine sand to a depth of about 40 inches. Below a depth of 40 inches the texture ranges from fine sand to silty clay.

Borup soils formed in the same kind of material as Glyndon soils and they are closely related to Colvin soils. They are more poorly drained than the Glyndon soils. They contain less clay than Colvin soils.

Borup loam (0 to 1 percent slopes) (Bo).—This soil is in shallow depressions and on slightly concave broad flats on the lake plain and the Sheyenne Delta. Areas are small in size and irregular in shape. This soil has the profile described as representative of the series.

This soil is poorly drained. Runoff is slow. The water table is near the surface in spring and during periods of heavy rainfall. The soil is moderately susceptible to soil blowing when the surface layer is bare and dry.

Most areas of this soil are used for crops. Some areas are in native grass hay and pasture. This soil is well suited to farming, if excess water is removed. The main concerns of management are removing excess water, maintaining fertility, and preventing soil blowing. Capability unit IIw-4L; Wet Meadow range site; windbreak suitability group 2.

Borup silt loam, very wet (0 to 1 percent slopes) (Br).—This soil is in deep depressions on the Sheyenne Delta and the lake plain. Areas are small in size and irregular in shape. This soil has a profile similar to that described as representative of the series, but the surface layer is silt loam.

This soil is poorly drained and it is frequently ponded. The water table is near the surface during most of the growing season.

Most areas of this soil are in native grass and and are used for pasture and hay. This soil is too wet for cultivation unless excess water is removed, but outlets generally are not available. The main concern of management is removing excess water. Capability unit Vw-WL; Wetland range site; windbreak suitability group 2.

Buse Series

The Buse series consists of deep, well-drained, undulating to hilly soils on till plains. These soils formed in medium-textured glacial till.

In a representative profile (fig. 10) the surface layer is black loam about 6 inches thick. The underlying material, to a depth of 60 inches, is calcareous loam glacial

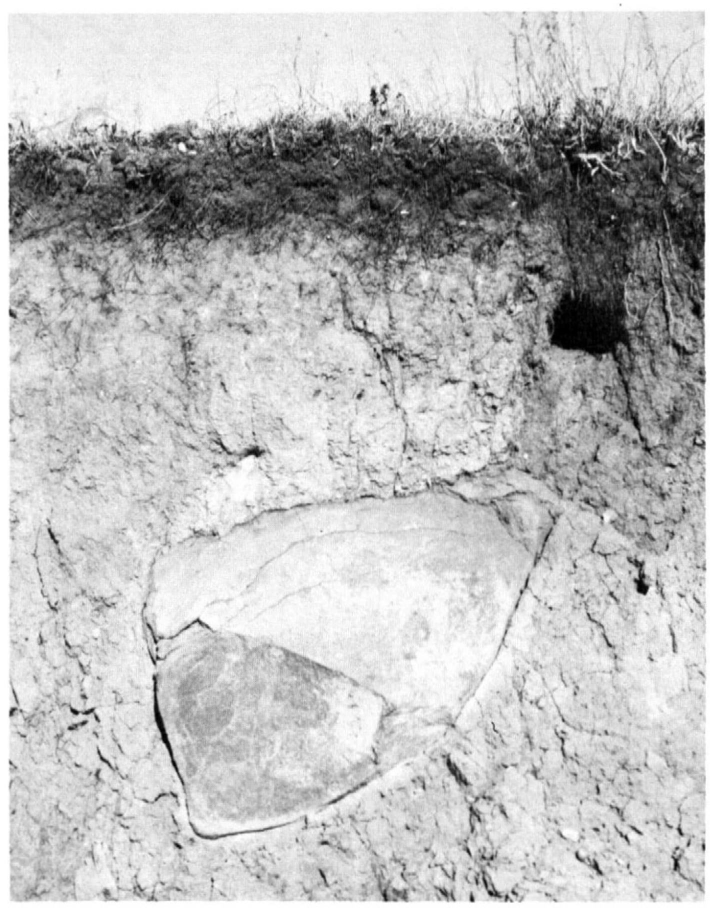

Figure 10.—**Profile of Buse loam showing thin surface layer.**

till. The upper 8 inches is dark grayish brown and the lower 52 inches is olive brown.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is moderate, and fertility is low. Runoff ranges from medium to very rapid.

The milder slopes of Buse soils are suited to farming. The hilly soils are better suited to hay and pasture grasses than to cultivated crops. Limitations for most nonfarm uses are slight to moderate. Most areas of Buse soils are used for pasture and hay. Some of the milder sloping areas are used for crops.

The Buse soils in this survey area are mapped only with Barnes, Forman, Langhei, and Svea soils.

Representative profile of Buse loam in an area of Barnes-Buse-Langhei loams, hilly, in a native pasture, 160 feet west and 1,075 feet north of the southeast corner of sec. 31, T. 130 N., R. 51 W.

A1—0 to 6 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; moderate, fine, granular structure; very friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

C1ca—6 to 14 inches, dark grayish-brown (10YR 4/2) loam; light brownish gray (10YR 6/2) when dry; moderate, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2—14 to 60 inches, olive-brown (2.5Y 4/3) loam; light brownish gray (2.5Y 6/2) when dry; moderate, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray and is 5 to 8 inches thick. The C horizon is loam or clay loam.

Buse soils formed in the same kind of material as the closely associated Barnes, Forman, Langhei, and Svea soils. They differ from Barnes, Forman, and Svea soils in not having a B horizon. They have a thinner solum than Barnes, Forman, and Svea soils. They have a darker colored A horizon than Langhei soils.

Cashel Series

The Cashel series consists of deep, somewhat poorly drained, nearly level, fine-textured soils on bottom land along streams. These soils formed in fine-textured alluvium.

In a representative profile the surface layer is very dark brown silty clay about 16 inches thick. The underlying material is very dark grayish-brown silty clay to a depth of 60 inches.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is moderate, and fertility is high. Runoff is slow. These soils are frequently flooded in spring, and they are occasionally flooded in summer when streams overflow.

Cashel soils are suited to cultivated crops. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops or pasture. Some areas are wooded.

Representative profile of Cashel silty clay in a bluegrass pasture, 4,125 feet east and 100 feet south of the northwest corner of sec. 5, T. 135 N., R. 48 W.

A11—0 to 7 inches, very dark brown (10YR 2/2) silty clay; dark gray (10YR 4/1) when dry; strong, fine, granular structure; friable, sticky and plastic; mildly alkaline; slight effervescence; clear, smooth boundary.

A12—7 to 16 inches, very dark brown (10 YR 2/2) silty clay; dark gray (10YR 4/1) when dry; weak, medium, prismatic structure parting to strong, very fine, subangular blocky; friable, sticky and plastic; mildly alkaline; slight effervescence; clear, smooth boundary.

C1—16 to 38 inches, very dark grayish-brown (2.5Y 3/2) silty clay; grayish brown (2.5Y 5/2) when dry; moderate, medium and fine, subangular blocky structure; friable, sticky and plastic; mildly alkaline; slight effervescence; gradual, wavy boundary.

C2—38 to 60 inches, very dark grayish-brown (2.5Y 3/2) silty clay; grayish brown (2.5Y 5/2) when dry; massive; friable, sticky and plastic; mildly alkaline; slight effervescence; few fine lime spots.

The A horizon is very dark brown or very dark grayish-brown silty clay or clay. One or more buried A horizons are above a depth of 60 inches in places. The C horizon is very dark grayish-brown or dark grayish-brown silty clay or clay.

Cashel soils are associated with Wahpeton soils, and they are closely related to Fairdale soils. They have a thinner, lighter colored A horizon and are more frequently flooded than Wahpeton soils. They are finer textured than Fairdale soils.

Cashel silty clay (0 to 3 percent slopes) (Ca).—This fine-textured soil is on bottom land along the Red River and its major tributaries. Areas are medium in size and irregular in shape.

This soil is somewhat poorly drained. It is frequently flooded in spring when the snow melts and in summer when the river overflows after heavy rains. Permeability is moderately slow, and the available water capacity is high. The hazard of erosion is slight.

This soil is suited to farming. Many areas are used for crops, but some large areas are in native woods. Farmers are concerned mainly with maintaining tilth and the level of fertility and with the hazard of flooding. Capability unit IIs-4; Overflow range site; windbreak suitability group 1.

Colvin Series

The Colvin series consists of deep, poorly drained, nearly level soils in shallow depressions and swales in the lake plain. These soils have a zone of lime accumulation within 16 inches of the surface. They formed in medium-textured and moderately fine textured lacustrine sediments.

In a representative profile the surface layer is silty clay loam about 14 inches thick. The upper 8 inches is black, and the lower 6 inches is dark gray. The underlying material, to a depth of about 28 inches, is light brownish-gray silty clay loam that contains a large amount of lime. Below this, to a depth of 60 inches, is olive and olive-gray silty clay loam mottled with yellowish brown and brown.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. Runoff is slow. The water table is within 1 to 3 feet of the surface early in spring and during periods of heavy rainfall.

Colvin soils are well suited to farming if excess water is removed. They are well suited to hay and pasture. Limitations for many nonfarm uses are severe. Most areas of Colvin soils are drained and used for cultivated crops. Some areas are in hay and pasture.

Representative profile of Colvin silty clay loam in a

cultivated field, 2,250 feet south and 120 feet west of the northeast corner of sec. 6, T. 134 N., R. 48 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; moderate, medium, subangular blocky structure; friable, sticky and plastic; neutral; slight effervescence; abrupt, smooth boundary.

A1ca—8 to 14 inches, dark-gray (2.5Y 4/1) silty clay loam; gray (2.5Y 6/1) when dry; moderate, coarse, subangular blocky structure; friable, sticky and plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

C1ca—14 to 28 inches, light brownish-gray (2.5Y 6/2) silty clay loam; light gray (2.5Y 7/2) when dry; moderate, fine, subangular blocky structure; friable, sticky and plastic; mildly alkaline; violent effervescence; clear, wavy boundary.

C2g—28 to 44 inches, olive (5Y 5/3) silty clay loam; pale yellow (5Y 7/3) when dry; common, fine, prominent, yellowish-brown (10YR 5/6) mottles; friable, sticky and plastic; neutral; slight effervescence; gradual, wavy boundary.

C3g—44 to 60 inches, olive-gray (5Y 5/2) silty clay loam; light gray (5Y 7/2) when dry; many, large, prominent, yellowish-brown (10YR 5/6) and brown (10YR 4/3 mottles; friable, sticky and plastic; neutral; slight effervescence.

The A horizon is very dark gray or black and is 8 to 14 inches thick. The depth to the Cca horizon ranges from 8 to 14 inches. It is gray, light brownish gray, or grayish brown. The C horizon is silt loam or silty clay loam. In some places there is a IIC horizon of silty clay or clay below a depth of 40 inches.

Colvin soils formed in the same kind of material as Bearden soils, and they are similar to Borup soils. They are more poorly drained than Bearden soils. They are finer textured than Borup soils.

Colvin silty clay loam (0 to 1 percent slopes) (Co).—This soil is in shallow depressions and swales on the lake plain. Included in mapping are areas where the surface layer is silt loam and small areas of Bearden and Perella soils.

This Colvin soil is poorly drained. Runoff is very slow. The water table is near the surface in spring and during periods of heavy rainfall. Permeability is moderately slow, and the available water capacity is high.

Most areas of this soil are used for crops. This soil is well suited to farming if excess water is removed. The main concerns of management are removing excess water and maintaining fertility. Capability unit IIw-4L; Wet Meadow range site; windbreak suitability group 2.

Dickey Series

The Dickey series consists of deep, well-drained, undulating soils on the Sheyenne Delta and the till plain. These soils are convex. They formed in coarse lacustrine and eolian deposits and the underlying medium-textured glacial till or lacustrine sediments.

In a representative profile the surface layer is black fine sandy loam about 12 inches thick. The subsoil is very friable, dark grayish-brown loamy sand about 16 inches thick. The underlying material, to a depth of about 34 inches, is grayish-brown loamy sand. Below this, to a depth of 60 inches, is glacial till of light olive-brown loam.

Permeability is rapid in the upper part of the profile and moderately slow in the underlying material. The available water capacity is moderate. The organic-matter content is moderate, and fertility is medium. Runoff is slow.

Dickey soils are suited to farming. Limitations for many nonfarm uses are slight to moderate. Most areas of these soils are used for crops.

Representative profile of Dickey fine sandy loam in an area of Dickey-Towner fine sandy loams, undulating, in a cultivated field, 740 feet south and 1,140 feet west of the northeast corner of sec. 10, T. 130 N., R. 51 W.

A1p—0 to 8 inches, black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—8 to 12 inches, black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

B2—12 to 28 inches, dark grayish-brown (10YR 4/2) loamy sand; grayish brown (10YR 5/2) when dry; weak, medium, prismatic structure parting to weak, medium, subangular blocky; very friable; neutral; clear, wavy boundary.

C1—28 to 34 inches, grayish-brown (2.5Y 5/2) loamy sand; light brownish gray (2.5Y 6/2) when dry; single grained; loose; neutral; mild effervescence; clear, wavy boundary.

IIC2—34 to 60 inches, light olive-brown (2.5Y 5/4) loam; light yellowish brown (2.5Y 6/3) when dry; few, fine, prominent, dark yellowish-brown (10YR 4/4) mottles; massive; friable, slightly sticky and plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray and is 8 to 14 inches thick. The B horizon is very dark grayish-brown, dark grayish-brown, or dark-brown loamy sand or loamy fine sand. The depth to the IIC horizon ranges from 25 to 40 inches. It is glacial till of loam or clay loam texture or silt loam lacustrine sediments.

Dickey soils are associated with Towner soils. They are better drained and are dark colored to a lesser depth than Towner soils.

Dickey-Towner fine sandy loams, undulating (3 to 6 percent slopes) (DkB).—This mapping unit is on low knolls on the Sheyenne Delta and the glacial till plain. It is about 60 percent Dickey fine sandy loam and about 40 percent Towner fine sandy loam. Areas are medium in size and irregular in shape.

The Dickey soil has the profile described as representative of the series. The Towner soil has a profile similar to that described as representative of the Towner series, but the surface layer is fine sandy loam.

Runoff is slow. Permeability is rapid in the surface layer and subsoil of these soils and moderately slow in the underlying material. The available water capacity is moderate. These soils are highly susceptible to soil blowing.

These soils are suited to farming, and most areas are used for cultivated crops. The main concerns of management are maintaining fertility, preventing soil blowing, and conserving water. Capability unit IIIe-3M; Sandy range site. Dickey soil in windbreak suitability group 5, Towner soil in windbreak suitability group 1.

Doran Series

The Doran series consists of deep, somewhat poorly drained, nearly level soils on the lake plain. These soils

are plane and convex. They formed in moderately fine textured lacustrine sediments and the underlying moderately fine textured glacial till.

In a representative profile the surface layer is black clay loam about 9 inches thick. The subsoil is about 11 inches thick. The upper part is very dark grayish-brown firm clay, and the lower part is olive-brown firm clay loam. To a depth of about 29 inches the underlying material is grayish-brown clay loam that contains a large amount of lime. Below this is grayish-brown grading to dark grayish-brown clay loam mottled with dark yellowish brown and brown.

Permeability is moderately slow in the upper part of the profile and slow in the underlying material. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow.

Doran soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Nearly all areas of these soils are used for crops.

Representative profile of Doran clay loam, 300 feet east and 2,455 feet north of the southwest corner of sec. 8, T. 129 N., R. 47 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam; very dark gray (10YR 3/1) when dry; moderate, fine and very fine, granular structure; friable, sticky and plastic; neutral; abrupt, smooth boundary.

B21t—9 to 15 inches, very dark grayish-brown (10YR 3/2) clay; dark gray (10YR 4/1) when dry; very dark brown (10YR 2/2) coats on peds; strong, medium, prismatic structure parting to strong, fine and very fine, angular blocky; firm, sticky and plastic; clay films on faces of peds; neutral; clear, irregular boundary.

B22t—15 to 20 inches, olive-brown (2.5Y 4/3) clay loam; grayish brown (2.5Y 5/2) when dry; moderate, medium, prismatic structure parting to moderate, fine, granular; firm, sticky and plastic; mildly alkaline; slight effervescence; clear, irregular boundary.

C1ca—20 to 29 inches, grayish-brown (2.5Y 5/2) clay loam; light brownish gray (2.5Y 6/2) when dry; common, fine, distinct, dark-brown (10YR 4/3) mottles; weak, fine, granular structure; friable, sticky and plastic; mildly alkaline; violent effervescence; few gypsum crystals; clear, wavy boundary.

C2—29 to 41 inches, grayish-brown (2.5Y 5/2) clay loam; light gray (2.5Y 7/1) when dry; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, very fine, subangular blocky structure; friable, slightly sticky and plastic; few iron concretions and shale chips; common gypsum crystals; mildly alkaline; slight effervescence; gradual, wavy boundary.

C3—41 to 60 inches, dark grayish-brown (2.5Y 4/2) clay loam; light gray (2.5Y 7/2) when dry; common, medium, distinct, dark-brown (10YR 4/3) mottles; moderate, fine, angular blocky structure; firm, slightly sticky and plastic; few iron concretions; few gypsum crystals; mildly alkaline; slight effervescence.

The A horizon is clay loam, silty clay loam, or loam 5 to 9 inches thick. The B horizon is 10 to 14 inches thick. It is very dark brown, very dark grayish-brown, dark grayish-brown, or olive-brown clay loam or clay. The depth to the Cca horizon ranges from 16 to 23 inches.

Doran soils are associated with Perella and Tonka soils. They are better drained than Perella and Tonka soils.

Doran clay loam (0 to 3 percent slopes) (Do).—This soil is on the lake plain. It is plane and convex. It has the profile described as representative of the series. Included in mapping are small areas of Antler and Tonka soils and small areas where the surface layer is loam.

This soil is somewhat poorly drained. Runoff is slow. Permeability is moderately slow in the surface layer and subsoil and slow in the underlying material. The hazard of erosion is slight.

This soil is well suited to farming, and most areas are used for cultivated crops. The main concerns of management are maintaining tilth and fertility and conserving water. Capability unit IIc-6; Clayey range site; windbreak suitability group 1.

Doran-Perella clay loams (0 to 3 percent slopes) (Dp).—This mapping unit is on the lake plain. It is about 65 percent Doran clay loam, about 25 percent Perella clay loam, and 10 percent small areas of Antler and Tonka soils. The Doran soil is plane and slightly convex, and the Perella soil is in shallow depressions.

The Perella soil has a profile similar to that described as representative of the Perella series, but the surface layer is clay loam and the underlying material, below a depth of about 30 inches, is glacial till of clay loam texture instead of silty clay or clay lacustrine sediments.

Doran clay loam is somewhat poorly drained and Perella clay loam is poorly drained. Runoff is slow, and the Perella soil is frequently ponded. The hazard of erosion is slight.

Most areas of this mapping unit are used for crops. The soils are well suited to farming if excess water is removed from the Perella soil. The main concerns of management are removing excess water and maintaining tilth and fertility. Capability unit IIw-6. Doran soil in Clayey range site and windbreak suitability group 1, Perella soil in Wet Meadow range site and windbreak suitability group 2.

Doran-Tonka silty clay loams (0 to 3 percent slopes) (Dt).—This mapping unit is on the lake plain. It is about 65 percent Doran silty clay loam, about 25 percent Tonka silty clay loam, and 10 percent small areas of Antler soils. The Doran soil is plane and slightly convex, and the Tonka soil is in shallow depressions.

The Doran soil has a profile similar to that described as representative of the series, but the surface layer is silty clay loam. The Tonka soil has a profile similar to that described as representative of the Tonka series, but the surface layer is silty clay loam and the underlying material is clay loam.

Doran silty clay loam is somewhat poorly drained, and Tonka silty clay loam is poorly drained. Runoff is slow. The Tonka soil is frequently ponded during periods of heavy rainfall. The hazard of erosion is slight.

Most areas are used for crops. The soils are well suited to farming if excess water is removed from the Tonka soil. The main concerns of management are removing excess water and maintaining tilth and fertility. Capability unit IIw-6. Doran soil in Clayey range site and windbreak suitability group 1, Tonka soil in Wet Meadow range site and windbreak suitability group 2.

Dovray Series

The Dovray series consists of deep, very poorly drained, fine-textured soils in depressions and swales in the lake plain. These soils formed in fine-textured lacustrine sediments.

In a representative profile the surface layer is black silty clay about 24 inches thick. The subsoil is dark-gray, firm clay about 20 inches thick. The underlying material is olive-gray clay mottled with yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow. These soils are frequently ponded unless drained.

Dovray soils are suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of these soils have been drained and are used for crops. Undrained areas are used mainly for hay and pasture.

Representative profile of Dovray silty clay in a cultivated field, 860 feet west and 1,000 feet south of the northeast corner of sec. 13, T. 133 N., R. 48 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay; very dark gray (10YR 3/1) when dry; moderate, very fine, crumb structure; firm, very sticky and very plastic; neutral; abrupt, smooth boundary.

A12—9 to 24 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate, very fine, angular, blocky structure; firm, very sticky and very plastic; neutral; gradual, wavy boundary.

B2g—24 to 44 inches, dark-gray (5Y 4/1) clay; gray (5Y 5/1) when dry; strong, fine, angular, blocky structure; firm, very sticky and very plastic; neutral; slight effervescence; clear, wavy boundary.

Cg—44 to 60 inches, olive-gray (5Y 5/2) clay; light olive gray (5Y 6/2) when dry; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; firm, very sticky and very plastic; mildly alkaline; strong effervescence; few soft masses of lime.

The A horizon is silty clay or clay 24 to 36 inches thick. The B horizon is dark-gray, dark grayish-brown, or olive-gray silty clay or clay. The depth to lime ranges from 24 to 40 inches. The C horizon is gray, grayish-brown, olive-gray, or light olive-gray silty clay or clay mottled with brown, dark yellowish brown, or yellowish brown.

Dovray soils formed in the same kind of material as Fargo and Grano soils. They are dark colored to a greater depth and are more poorly drained than Fargo soils. They are dark colored and free of lime to a greater depth than Grano soils.

Dovray silty clay (0 to 1 percent slopes) (Dv).—This very poorly drained, fine-textured soil is in shallow to deep depressions in the lake plain. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Grano soils.

Runoff is very slow and this Dovray soil is frequently ponded in spring and during periods of heavy rainfall. Permeability is slow.

This soil is suited to farming if excess water is removed. Some areas have been drained and are used for crops. Undrained areas are used mainly for hay and pasture. The main concerns of management are removing excess water and maintaining tilth and fertility in areas that are used for crops. Capability unit IIIw-4; Wetland range site; windbreak suitability group 2.

Eckman Series

The Eckman series consists of deep, well-drained, undulating to hilly soils along streams that cut through the lake plain and the Sheyenne Delta. These soils formed in medium and coarse-textured lacustrine material.

In a representative profile the surface layer is black silt loam about 8 inches thick. The subsoil is friable silt loam about 11 inches thick. The upper part is very dark grayish brown, and the lower part is dark grayish brown. The underlying material, to a depth of about 48 inches, is light olive-brown silt loam. Below this is light olive-brown very fine sandy loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is medium to rapid.

The milder slopes of Eckman soils are well suited to farming. Hilly phases are better suited to hay and pasture than to cultivated crops. Most areas are used for crops. A few steeper areas are used for pasture. Limitations for many nonfarm uses are slight to moderate.

Representative profile of Eckman silt loam from an area of Gardena-Eckman silt loams, undulating, in a cultivated field, 1,735 feet east and 495 feet north of the southwest corner of sec. 32, T. 136 N., R. 51 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

B21—8 to 13 inches, very dark grayish-brown (10YR 3/2) silt loam; dark grayish brown (10YR 4/2) when dry; weak, coarse, prismatic structure; friable, slightly sticky and slightly plastic; neutral; gradual, wavy boundary.

B22—13 to 19 inches, dark grayish-brown (10YR 4/2) silt loam; grayish brown (10YR 5/2) when dry; weak, coarse, prismatic structure; friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

C1ca—19 to 40 inches, light olive-brown (2.5Y 5/3) silt loam; pale yellow (2.5Y 7/3) when dry; weak, medium, subangular blocky structure; mildly alkaline; strong effervescence; gradual, wavy boundary.

C2—40 to 48 inches, light olive-brown (2.5Y 5/4) silt loam; pale yellow (2.5Y 7/4) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; slight effervescence; clear, wavy boundary.

C3—48 to 60 inches, light olive-brown (2.5Y 5/3) very fine sandy loam; pale yellow (2.5Y 7/3) when dry; massive; very friable; neutral; slight effervescence.

The solum ranges from 15 to 30 inches in thickness. The A horizon is black or very dark gray silt loam or very fine sandy loam 7 to 14 inches thick. The B horizon is very dark grayish-brown, dark-brown, or brown silt loam or very fine sandy loam. The Cca horizon is at a depth of 15 to 30 inches. The C horizon is silt loam or very fine sandy loam.

Eckman soils are associated with Gardena and Zell soils. They are dark colored to a lesser depth and are better drained than Gardena soils. They differ from Zell soils in having a B horizon.

Eckman-Zell silt loams, rolling (6 to 9 percent slopes) (EeC).—This mapping unit is on slopes and breaks along streams that cut through the Sheyenne Delta and the lake plain. It is about 60 percent Eckman silt loam and about 40 percent Zell silt loam. Included in mapping are small areas that have a surface layer of fine sandy loam. The Zell soil is on the hilltops and upper parts of hillsides and the Eckman soil is on the lower parts of hillsides.

These soils are well drained. Permeability is moderate, and the available water capacity is high. Runoff is rapid. The hazard of erosion is severe. These soils are also moderately susceptible to soil blowing.

These soils are suited to farming, and most areas are

used for cultivated crops. The main concerns of management are preventing water erosion and soil blowing, conserving water, and maintaining fertility. Capability unit IIIe-5. Eckman soil in Silty range site and windbreak suitability group 3, Zell soil in Thin Upland range site and windbreak suitability group 8.

Egeland Series

The Egeland series consists of deep, well-drained, undulating soils on convex surfaces on the Sheyenne Delta and the lake plain. These soils formed in moderately coarse textured lacustrine sediments.

In a representative profile the surface layer is black fine sandy loam about 7 inches thick. The subsoil is very friable fine sandy loam about 29 inches thick. The upper part is very dark grayish brown, and the lower part is dark yellowish brown. The underlying material is light olive-brown fine sandy loam.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is moderate. Fertility is medium. Runoff is slow.

Egeland soils are suited to cultivated crops. Limitations for many nonfarm uses are slight to severe. Most areas of these soils are used for cultivated crops. Some small areas are in pasture.

Representative profile of Egeland fine sandy loam from an area of Egeland and Maddock fine sandy loams, undulating, in a cultivated field, 400 feet west and 1,100 feet south of the northeast corner of sec. 20, T. 129 N., R. 49 W.

Ap—0 to 7 inches, black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; slightly acid; abrupt, smooth boundary.

B2—7 to 15 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; dark grayish brown (10YR 4/2) when dry; weak, medium, prismatic structure parting to weak, medium, subangular blocky; very friable; slightly acid; clear, wavy boundary.

B3—15 to 36 inches, dark yellowish-brown (10YR 4/4) fine sandy loam; brown (10YR 5/3) when dry; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; very friable; slightly acid; gradual, wavy boundary.

C—36 to 60 inches, light olive-brown (2.5Y 5/3) fine sandy loam; light yellowish brown (2.5Y 6/3) when dry; weak, coarse, subangular blocky structure parting to single grained; very friable; mildly alkaline; slight effervescence.

The solum ranges from 20 to 40 inches in thickness. The A horizon is black or very dark gray and is 6 to 12 inches thick. The B horizon is very dark grayish-brown, dark grayish-brown, dark-brown, or dark yellowish-brown sandy loam or fine sandy loam. The C horizon is fine sandy loam or sandy loam to a depth of about 40 inches. Below 40 inches it is loamy sand, loamy fine sand, sandy loam, or fine sandy loam.

Egeland soils are associated with Maddock soils, and they formed in the same kind of material as Embden soils. They are finer textured in the B horizon and upper part of the C horizon than Maddock soils. They are better drained and are dark colored to a lesser depth than Embden soils.

Egeland and Maddock fine sandy loams, undulating (3 to 6 percent slopes) (EmB).—This mapping unit is on low knolls and side slopes in the Sheyenne Delta. Some areas are Egeland fine sandy loam, some are Maddock fine sandy loam, and some areas contain both soils.

The Egeland soil has the profile described as representative of the series. The Maddock soil has a profile similar to that described as representative of the Maddock series, but it has a fine sandy loam surface layer.

Both soils are well drained. Runoff is slow. The Egeland soil has moderately rapid permeability and moderate available water capacity. The Maddock soil has rapid permeability and low available water capacity. Both are highly susceptible to soil blowing.

These soils are suited to farming. Most areas are used for crops. Preventing soil blowing, conserving water, and maintaining fertility are the main concerns of management. Capability unit IIIe-3; Sandy range site; windbreak suitability group 5.

Embden Series

The Embden series consists of deep, moderately well drained, nearly level soils on the lake plain and the Sheyenne Delta. These soils are plane and slightly convex. They formed in moderately coarse textured lacustrine sediments.

In a representative profile the surface layer is very dark gray fine sandy loam about 18 inches thick. The subsoil is very dark grayish-brown very friable fine sandy loam about 18 inches thick. The underlying material is olive-brown fine sandy loam.

Permeability is moderately rapid, and the available water capacity is moderate or high. The organic-matter content is high. Fertility is high. Runoff is slow.

Embden soils are well suited to farming. Limitations for many nonfarm uses are moderate to severe. Most areas of Embden soils are used for cultivated crops. Some areas are in pasture and hay.

Representative profile of Embden fine sandy loam in an area of Embden-Tiffany fine sandy loams, in a cultivated field, 112 feet west and 2,380 feet north of the southeast corner of sec. 19, T. 134 N., R. 52 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—8 to 18 inches, very dark gray (10YR 3/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; neutral; gradual, wavy boundary.

B2—18 to 36 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; dark grayish brown (10YR 4/2) when dry; weak, medium and coarse, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

C—36 to 60 inches, olive-brown (2.5Y 4/3) fine sandy loam; grayish brown (2.5Y 5/2) when dry; weak, medium, subangular blocky structure parting to single grained; very friable; neutral; slight effervescence.

The A horizon is black or very dark gray fine sandy loam, very fine sandy loam, or loam, 10 to 20 inches thick. The B horizon is very dark brown, very dark grayish brown, or dark grayish brown and is 10 to 24 inches thick. The upper part of the C horizon, to a depth of about 40 inches, is fine sandy loam. Below a depth of 40 inches it ranges from loamy fine sand to silty clay. In some places few to many yellowish-brown or dark-brown mottles are in the C horizon.

Embden soils are associated with Gardena and Tiffany soils, and they formed in the same kind of material as Egeland soils. They are coarser textured in the B horizon and

Figure 11.—**Corn, one of the principal crops on Embden-Tiffany fine sandy loams.**

upper part of the C horizon than Gardena soils. They are better drained and have fewer mottles at a lesser depth than Tiffany soils. They are more poorly drained and are dark colored to a greater depth than Egeland soils.

Embden-Tiffany fine sandy loams (0 to 3 percent slopes) (En).—This mapping unit is on the Sheyenne Delta. It is about 70 percent Embden fine sandy loam and about 30 percent Tiffany fine sandy loam. Areas are plane and slightly concave. The Tiffany soil is in slightly depressed areas, and the Embden soil is in slightly higher positions. Included in mapping are small areas of Wyndmere soils.

The Embden soil in this complex has the profile described as representative of the series. The Tiffany soil has a profile similar to that described as representative of the Tiffany series, but the surface layer is fine sandy loam.

The Embden soil is moderately well drained, and the Tiffany soil is poorly drained. Runoff is slow, and permeability is moderately rapid. These soils are highly susceptible to soil blowing.

These soils are well suited to farming, and most areas are used for cultivated crops (fig. 11). The main concerns of management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIIe-3. Embden soil in Sandy range site and windbreak suitability group 1, Tiffany soil in Subirrigated range site and windbreak suitability group 2.

Embden-Tiffany loams (0 to 3 percent slopes) (Et).—This mapping unit is on the Sheyenne Delta. It is about 70 percent Embden loam and about 30 percent Tiffany loam. Areas are plane and slightly concave. The Tiffany soil is in slightly depressed areas and the Embden soil is in slightly higher positions. Included in mapping are small areas of Wyndmere soils.

The Embden soil in this complex has a profile similar to that described as representative of the series, but the surface layer is loam.

The Embden soil is moderately well drained, and the Tiffany soil is poorly drained. Runoff is slow, and permeability is moderately rapid. These soils are moderately susceptible to soil blowing.

These soils are well suited to farming, and most areas are used for cultivated crops. The main concerns of management are conserving moisture, preventing soil blowing, and maintaining fertility. Capability unit IIe-5. Embden soil in Sandy range site and windbreak suitability group 1, Tiffany soil in Subirrigated range site and windbreak suitability group 2.

Enloe Series

The Enloe series consists of deep, poorly drained, nearly level soils in shallow depressions in the lake plain. These soils formed in fine-textured lacustrine sediments.

In a representative profile the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is very dark gray silty clay loam about 6 inches thick. The subsoil is very firm clay about 26 inches thick. The upper part is black, the middle part is very dark gray, and the lower part is dark gray. The underlying material is olive-gray clay mottled with olive brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high. Fertility is high. Runoff is slow, and these soils are frequently ponded unless they are drained.

Enloe soils are well suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of these soils have been drained and are used for crops.

The Enloe soils in this survey area are mapped only with Fargo and Galchutt soils.

Representative profile of Enloe silty clay loam in an area of Fargo-Enloe silty clay loams in a cultivated field, 800 feet east and 310 feet north of the southwest corner of sec. 17, T. 135 N., R. 48 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; strong, fine and very fine, granular structure; firm, sticky and very plastic; medium acid; abrupt, smooth boundary.

A2—8 to 14 inches, very dark gray (10YR 3/1) silty clay loam; gray (10YR 5/1) when dry; dark-gray (10YR 4/1) silt coats on faces of peds; weak, coarse, prismatic structure parting to moderate, thin, platy; friable, sticky and plastic; medium acid; abrupt, wavy boundary.

B21t—14 to 18 inches, black (5Y 2/1) clay; very dark gray 5Y 3/1) when dry; moderate, very coarse, prismatic structure parting to strong, fine and very fine, angular blocky; very firm, very sticky and very plastic; slightly acid; abrupt, wavy boundary.

B22tg—18 to 29 inches, very dark gray (5Y 3/1) clay; dark gray (5Y 4/1) when dry; moderate, very coarse, prismatic structure parting to strong, fine, angular blocky; very firm, very sticky and very plastic; neutral; clear, wavy boundary.

B3g—29 to 40 inches, dark-gray (5Y 4/1) clay; gray (5Y 6/1) when dry; moderate, very coarse, prismatic structure parting to strong, fine and very fine, angular blocky; very firm, very sticky and very plastic; slight effervescence; mildly alkaline; gradual, wavy boundary.

Cg—40 to 60 inches, olive-gray (5Y 4/2) clay; light olive gray (5Y 6/2) when dry; few, fine, faint, olive-brown (2.5Y 4/4) mottles; moderate, medium and fine, angular blocky structure; firm, very sticky and very plastic; mildly alkaline; slight effervescence; few small lime concretions.

The A1 horizon is black or very dark gray and is 7 to 14 inches thick. The A2 horizon is 2 to 10 inches thick and is mottled in places with yellowish brown. The B horizon is black, very dark gray, very dark grayish-brown, or dark-gray clay or silty clay, 12 to 36 inches thick. The C horizon is clay or silty clay, but in some places, below a depth of about 30 inches, it is glacial till of clay mixture.

Enloe soils are associated with Fargo and Galchutt soils. They differ from Fargo soils in having an A2 horizon. They have more clay in the A1 and A2 horizons and are more poorly drained than Galchutt soils.

Exline Series

The Exline series consists of deep, somewhat poorly drained, level soils on the lake plain. These soils have a claypan. They are plane and slightly concave. They formed in medium textured and moderately fine textured lacustrine sediments.

In a representative profile the surface layer is black silt loam about 3 inches thick. The subsurface layer is dark-gray silt loam about 2 inches thick. The subsoil is very dark grayish-brown very firm silty clay loam about 12 inches thick. The underlying material, to a depth of about 37 inches, is olive-gray silty clay loam that contains a large amount of lime and salt crystals. The next layer, about 9 inches thick, is olive-gray silt loam mottled with yellowish brown. Below this is light olive-brown silt loam mottled with dark yellowish brown and yellowish brown.

Permeability is very slow in the dense claypan subsoil. The available water capacity is low because the underlying material is saline. The organic-matter content is moderate, and fertility is low. Runoff is slow.

Exline soils are better suited to hay and pasture grasses than to cultivated crops. Limitations for many nonfarm uses are moderate to severe. Most areas of these soils are used for hay or pasture. Some areas are used for crops.

Representative profile of Exline silt loam in an area of Exline and Ryan soils in a native grass pasture, 320 feet south and 1,580 feet west of the northeast corner of sec. 34, T. 134 N., R. 51 W.

A1—0 to 3 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; moderate, fine, granular structure; friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

A2—3 to 5 inches, dark-gray (10YR 4/1) silt loam; gray (10YR 6/1) when dry; weak, thin, platy structure; very friable; neutral; abrupt, smooth boundary.

B2t—5 to 17 inches, very dark grayish-brown (10YR 3/2) silty clay loam; dark gray (10YR 4/1) when dry; moderate, medium, columnar structure parting to strong, medium, angular blocky; very firm, sticky and plastic; thin continuous clay films on all ped faces; few fine salt and gypsum crystals in lower part of horizon; moderately alkaline; gradual, wavy boundary.

C1casa—17 to 37 inches, olive-gray (5Y 5/2) silty clay loam; light gray (5Y 7/2) when dry; few, fine, prominent, light olive-brown (2.5Y 5/6) mottles; moderate, fine, angular blocky structure; firm, sticky and plastic; strongly alkaline; strong effervescence; common medium salt crystals; clear, wavy boundary.

C2g—37 to 46 inches, olive-gray (5Y 5/2) silt loam; light gray (5Y 7/2) when dry; many, medium, prominent, yellowish-brown (10YR 5/6) mottles; friable, slightly sticky and slightly plastic; moderately alkaline; slight effervescence; gradual, wavy boundary.

C3g—46 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; pale yellow (2.5Y 7/4) when dry; many, large, prominent, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) mottles; friable, slightly sticky and slightly plastic; moderately alkaline; slight effervescence.

The A1 and A2 horizons combined are 2 to 5 inches thick. The A1 horizon is black or very dark gray and is 1 to 3 inches thick. The A2 horizon is very dark gray, dark gray, or gray and is less than 1 to 3 inches thick. The B2 horizon is black, very dark brown, very dark gray, or very dark grayish-brown silty clay loam, silty clay, or clay. The C horizon is silt loam or silty clay loam.

Exline soils are similar to Ryan soils. They are better drained and contain less clay and more silt than Ryan soils.

Exline and Ryan soils (0 to 3 percent slopes) (Ey).—This mapping unit is on the lake plain. Some areas are Exline silt loam, some areas are Ryan silty clay loam, and some areas are both. These soils have a shallow claypan subsoil. Included in mapping are small areas of Fargo soils. The Exline soil has the profile described as representative of the series.

Runoff is slow, and permeability is very slow. The available water capacity is low because the salt content is high.

Some areas of these soils are used for crops, but most areas are used for hay and pasture. The soils are better suited to hay and pasture grasses than to cultivated crops because their claypan subsoil restricts downward root growth and penetration of water. If these soils are tilled, the claypan subsoil is mixed with the surface layer and they become very sticky when they are wet and hard and crusted when they are dry. Good tilth is very difficult to maintain. Capability unit VIs-TCp; Thin Claypan range site; windbreak suitability group 9.

Fairdale Series

The Fairdale series consists of deep, moderately well drained, nearly level to undulating soils on stream bottom lands and terraces. These soils formed in medium textured and moderately fine textured alluvium.

In a representative profile the surface layer is silt loam about 22 inches thick. The upper 5 inches is very dark grayish brown, the next 9 inches is very dark brown, and the lower 8 inches is very dark grayish brown. The underlying material, to a depth of 48 inches, is dark-brown silt loam. Below this is very dark grayish-brown silt loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate. Fertility is high. Runoff is slow to medium. This soil is frequently flooded early in spring when streams are at flood stage.

Fairdale soils are well suited to farming. Limitations for many nonfarm uses are severe. Most areas of these soils are in native woods. Some areas are used for crops and some are in pasture.

Representative profile of Fairdale silt loam, channeled, in a wooded area, 1,230 feet south and 2,800 feet west of the northeast corner of sec. 4, T. 135 N., R. 52 W.

A11—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) when dry; moderate, fine, crumb structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; clear, smooth boundary.

A12—5 to 14 inches, very dark brown (10YR 2/2) silt loam; dark gray (10YR 4/1) when dry; moderate, fine and medium, crumb structure; friable, slightly sticky and slightly plastic; mildly alkaline; slight effervescence; clear, smooth boundary.

A13—14 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) when dry; moderate, fine and medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C—22 to 48 inches, dark grayish-brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) when dry; moderate, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

A1b—48 to 60 inches, very dark grayish-brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) when dry; weak, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon is silt loam or silty clay loam. One or more buried A horizons are within the profile. The C horizon ranges from very fine sandy loam to silty clay loam.

Fairdale soils formed in the same kind of material as LaDelle and LaPrairie soils, and they are closely related to Cashel soils. They are lighter colored than LaDelle and LaPrairie soils. They contain less clay than Cashel soils.

Fairdale silt loam (0 to 3 percent slopes) (Fa).—This soil is on stream bottom lands and terraces. Areas are medium in size and irregular in shape. Included in mapping are small areas of LaPrairie soils.

This Fairdale soil is moderately well drained. Runoff is slow, and permeability is moderate. The hazard of erosion is slight. Flooding is frequent when streams overflow in spring after rapid snowmelt and in summer after heavy rains.

This soil is well suited to farming. Most areas are used for crops. Some areas remain in native woods. The main concern of management is maintaining fertility, and the main limitation is the hazard of flooding. Capability unit IIc-6; Overflow range site; windbreak suitability group 1.

Fairdale silt loam, channeled (3 to 6 percent slopes) (Fb).—This soil is on stream bottom lands and terraces that have been moderately cut by oxbows and abandoned channels. It has the profile described as representative of the series. Included in mapping are small areas of LaPrairie and LaDelle soils and small areas where the surface layer is silty clay loam.

This Fairdale soil is well drained. Runoff is medium, and permeability is moderate. The hazard of erosion is moderate. Flooding is frequent when streams overflow in spring after rapid snowmelt and in summer after heavy rains.

This soil is well suited to farming. Some areas are used for crops, but many areas are in native woods. The main concerns of management are maintaining fertility and preventing water erosion. The main limitation is the hazard of flooding. Capability unit IIe-6; Silty range site; windbreak suitability group 1.

Fairdale silty clay loam (0 to 3 percent slopes) (Fd).—This soil is on stream bottom lands and terraces. It has a profile similar to that described as representative of the series, but the surface layer is silty clay loam. Included in mapping are small areas of LaDelle soils.

This Fairdale soil is moderately well drained. Runoff is slow. Permeability is moderate. The hazard of erosion is slight. Flooding is frequent when streams overflow in spring after rapid snowmelt and early in summer after heavy rains.

This soil is well suited to farming. Some areas are used for crops, but many areas remain in native woods. The main concern of management is maintaining fertility, and the main limitation is the hazard of flooding.

Capability unit IIc-6; Overflow range site; windbreak suitability group 1.

Fargo Series

The Fargo series consists of deep, poorly drained, nearly level to gently sloping, fine-textured soils on the lake plain. These soils are plane or slightly concave. They formed in fine-textured lacustrine sediments.

In a representative profile the surface layer is black silty clay about 8 inches thick. The subsoil is very dark gray, very firm clay about 9 inches thick. The underlying material, to a depth of 60 inches, is olive-gray clay mottled with light olive brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow.

Fargo soils are well suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Nearly all areas of these soils are used for crops.

Representative profile of Fargo silty clay in a cultivated field, 2,600 feet south and 145 feet east of the northwest corner of sec. 1, T. 135 N., R. 49 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay; very dark gray (10YR 3/1) when dry; strong, fine, granular structure; firm, very sticky and very plastic; neutral; abrupt, smooth boundary.

B2g—8 to 17 inches, very dark gray (5Y 3/1) clay; dark gray (5Y 4/1) when dry; strong, very fine, angular blocky structure; very firm, very sticky and very plastic; neutral; gradual, wavy boundary.

C1gca—17 to 35 inches, olive-gray (5Y 4/2) clay; gray (5Y 5/1) when dry; moderate, fine, angular blocky structure; very firm, very sticky and very plastic; mildly alkaline; strong effervescence; few lime nodules; clear, wavy boundary.

C2g—35 to 60 inches, olive-gray (5Y 5/2) clay; light olive gray (5Y 6/2) when dry; many, medium, faint, light olive-brown (2.5Y 5/4) mottles; massive; very firm, very sticky and very plastic; mildly alkaline; strong effervescence.

The A horizon is clay, silty clay, or silty clay loam 6 to 20 inches thick. Tongues of the A horizon extend to a depth of 36 inches in some places. The B horizon is 8 to 16 inches thick. It is black, very dark gray, dark-gray, very dark grayish-brown, dark grayish-brown, dark olive-gray, or olive-gray silty clay or clay. The C horizon is ordinarily silty clay or clay lacustrine sediments, but in some places below a depth of 30 inches it is glacial till of clay loam or clay texture.

Fargo soils formed in the same kind of material as the associated Dovray, Enloe, Hegne, and Ryan soils. They are also associated with Galchutt soils. They are dark colored to a lesser depth than Dovray soils. They do not have the A2 horizon that is typical of Enloe and Galchutt soils. They are deeper over a lime zone than Hegne soils. They have a thicker A horizon and a lower concentration of sodium salts in the B horizon than Ryan soils.

Fargo silty clay loam (0 to 3 percent slopes) (Fe).—This soil is on the lake plain, in broad areas that are medium to large in size and irregular in shape. It has a profile similar to that described as representative of the series, but the surface layer is silty clay loam. Included in mapping are small areas of Hegne and Enloe soils.

This Fargo soil is poorly drained. Runoff is slow, and some areas are flooded after heavy rains or rapid snowmelt. Permeability is slow. The hazard of erosion is slight.

This soil is well suited to farming if excess water is removed. Most areas are used for crops. The main concerns in management are removing excess water and maintaining tilth and the level of fertility. Capability unit IIw-6; Clayey range site; windbreak suitability group 1.

Fargo silty clay (0 to 3 percent slopes) (Ff).—This soil is on the lake plain, in broad areas that are medium to large in size and irregular in shape. It has the profile described as representative of the series. Included in mapping are small areas of Hegne and Enloe soils.

This Fargo soil is poorly drained. Runoff is very slow, and some areas are flooded after heavy rains or rapid snowmelt. Permeability is slow. The soil is difficult to work and to keep in good tilth. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

This soil is well suited to farming if excess water is removed and good tilth is maintained. Most areas are used for crops (fig. 12). The main concerns in management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility. Capability unit IIwe-4; Clayey range site; windbreak suitability group 1.

Fargo silty clay, depressional (0 to 1 percent slopes) (Fg).—This shallow soil is in small, irregularly shaped areas on the lake plain. Included in mapping are small areas of Enloe and Dovray soils.

This Fargo soil is poorly drained. Runoff is very slow, and ponding frequently occurs after heavy rains and rapid snowmelt. Permeability is slow. The soil is difficult to work and to keep in good tilth. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

This soil is well suited to farming if excess water is removed and good tilth is maintained. Most areas are used for crops. The main concerns in management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility. Capability unit IIwe-4; Clayey range site; windbreak suitability group 1.

Fargo silty clay, gently sloping (3 to 6 percent slopes) (FhB).—This soil is on the slopes and breaks of small streams on the lake plain. Areas are small and irregularly shaped. Included in mapping are small areas of Nutley and Hegne soils.

Runoff is medium, and permeability is slow. The hazard of water erosion is moderate. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring. The soil is difficult to work and to keep in good tilth.

This soil is well suited to farming if good tilth is maintained. Most areas are used for crops. The main concerns in management are preventing erosion and maintaining tilth and the level of fertility. Capability unit IIe-4; Clayey range site; windbreak suitability group 1.

Fargo silty clay, till substratum (0 to 3 percent slopes) (Fk).—This soil is on the lake plain, in broad areas that are medium in size and irregular in shape. It has a profile similar to that described as representative of the series, but the substratum below a depth of about 30 inches is glacial till of clay loam or clay texture.

Figure 12.—**Soybeans, the chief row crop, on Fargo silty clay.**

Included in mapping are small areas of Hegne and Enloe soils.

This Fargo soil is poorly drained. Runoff is very slow, and some areas are flooded after heavy rains and rapid snowmelt. Permeability is slow. The soil is difficult to work and to keep in good tilth. If the surface is left bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

This soil is well suited to farming if excess water is removed and good tilth is maintained. Most areas are used for crops. The main concerns in management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility. Capability unit IIwe-4; Clayey range site; windbreak suitability group 1.

Fargo-Enloe silty clay loams (0 to 1 percent slopes) (Fm).—This mapping unit is on broad flats on the lake plain. It is about 65 percent Fargo silty clay loam and about 35 percent Enloe silty clay loam. The Enloe soil is in slightly depressed areas and the Fargo soil is in slightly higher positions. Areas are medium in size and irregular in shape. Included in mapping are small areas of Hegne and Ryan soils.

The Fargo soil in this mapping unit has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam. The Enloe soil has the profile described as representative of the Enloe series.

These soils are poorly drained. Runoff is very slow. The Enloe soil is frequently ponded after heavy rains or rapid snowmelt. Permeability is slow. The hazard of erosion is slight.

These soils are well suited to farming if excess water is removed. Most areas are used for crops. The main concerns in management are removing excess water and maintaining tilth and the level of fertility. Capability unit IIw-6. Fargo soil in Clayey range site and windbreak suitability group 1, Enloe soil in Wet Meadow range site and windbreak suitability group 2.

Fargo-Enloe complex, till substratum (0 to 3 percent slopes) (Fn).—This mapping unit is on broad flats on the lake plain. It is about 70 percent Fargo silty clay, till substratum, and about 30 percent Enloe silty clay loam, till substratum. The Enloe soil is in shallow depressions, and the Fargo soil is in slightly higher positions. Areas are medium in size and irregular in shape. Included in mapping are small areas of Hegne soils.

The Fargo and Enloe soils have profiles similar to those described as representative of their respective

series, but the material below a depth of about 30 inches is glacial till of clay loam or clay texture.

These soils are poorly drained. Runoff is very slow. The Enloe soil is frequently ponded after heavy rains and rapid snowmelt. Permeability is slow. The Fargo soil is difficult to work and to keep in good tilth. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

These soils are well suited to farming if excess water is removed and good tilth is maintained. Most areas are used for crops. The main concerns in management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility. Capability unit IIwe-4. Fargo soil in Clayey range site and windbreak suitability group 1, Enloe soil in Wet Meadow range site and windbreak suitability group 2.

Fargo-Hegne silty clays (0 to 3 percent slopes) (Fo).—This mapping unit is on broad flats on the lake plain. It is about 60 percent Fargo silty clay and about 40 percent Hegne silty clay. Areas are medium or large in size and irregular in shape. Included in mapping are small areas of Enloe soils. The Hegne soil has the profile described as representative of the series.

The Fargo and Hegne soils are poorly drained. Runoff is very slow, and some areas are occasionally ponded after heavy rains or rapid snowmelt. Permeability is slow. The soils are difficult to work and to keep in good tilth. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

These soils are well suited to farming if excess water is removed and good tilth is maintained. Most areas are used for crops. The main concerns in management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility. Capability unit IIwe-4; Clayey range site; windbreak suitability group 1.

Fargo-Hegne silty clays, till substratum (0 to 3 percent slopes) (Fp).—This mapping unit is on broad flats on the lake plain. It is about 60 percent Fargo silty clay and about 40 percent Hegne silty clay. Areas are medium in size and irregular in shape. Included in mapping are small areas of Enloe soils.

Both the Fargo and Hegne soils in this complex have a profile similar to that described as representative of their series, but the substratum below a depth of about 30 inches is glacial till of clay loam or clay texture.

These soils are poorly drained. Runoff is very slow, and some areas are occasionally ponded after heavy rains or rapid snowmelt. Permeability is slow. The soils are difficult to work and to keep in good tilth. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

These soils are well suited to farming if excess water is removed and good tilth is maintained. Most areas are used for crops. The main concerns in management are removing excess water, preventing soil blowing, and maintaining tilth and the level of fertility. Capability unit IIwe-4; Clayey range site; windbreak suitability group 1.

Fargo-Ryan silty clay loams (0 to 1 percent slopes) (Fr).—This mapping unit is on broad flats on the lake plain. It is about 70 percent Fargo silty clay loam and about 30 percent Ryan silty clay loam. Areas are medium to large in size and uneven in shape. Included in mapping are small areas of Enloe and Galchutt soils.

The Fargo soil has a profile similar to that described as representative of the series, but the surface layer is silty clay loam. The Ryan soil has the profile described as representative of the series.

Fargo and Ryan soils are poorly drained. Permeability is slow in the Fargo soil and very slow in the Ryan soil. The Ryan soil is very shallow over a dense claypan subsoil that restricts downward movement of water and development of roots. Runoff is very slow, and some areas are occasionally flooded after heavy rains or rapid snowmelt. The Ryan soil is difficult to work and to keep in good tilth. The claypan subsoil is mixed with the surface layer in tillage, and it becomes very sticky when wet and very hard and crusted as it dries. The hazard of soil blowing is moderate.

These soils are suited to farming, and most areas are used for crops. Crops do not grow so well on the Ryan soil as on the Fargo soil because the Ryan soil has low available water capacity and salts in the subsoil. The main concerns in management are maintaining tilth and the level of fertility, removing excess water, and preventing soil blowing. Capability unit IIIs-P4. Fargo soil in Clayey range site and windbreak suitability group 1, Ryan soil in Thin Claypan range site and windbreak suitability group 9.

Fargo-Ryan silty clays (0 to 1 percent slopes) (Fs).—This mapping unit is on broad flats on the lake plain. It is about 80 percent Fargo silty clay and about 20 percent Ryan silty clay. Areas are medium to large in size and irregular in shape. Included in mapping are small areas of Enloe soils.

The Fargo soil has the profile described as representative of the series. The Ryan soil has a profile similar to that described as representative of the Ryan series, but the surface layer is silty clay.

Fargo and Ryan soils are poorly drained. Runoff is very slow, and some areas are occasionally flooded after heavy rains or rapid snowmelt. Permeability is slow in the Fargo soil and very slow in the Ryan soil. The Ryan soil has a dense claypan subsoil that contains a large amount of sodium salts. The claypan restricts downward movement of water and development of roots.

Fargo and Ryan soils are difficult to work and to keep in good tilth. The claypan subsoil of the Ryan soil is mixed with the surface layer in tillage, and it becomes very sticky when wet and hard and crusty as it dries. If the surface is bare and dry, soil blowing is a moderate hazard late in winter and early in spring.

These soils are suited to farming, and most areas are used for crops. Crop growth is not so favorable on the Ryan soil as on the Fargo soil because the Ryan soil has low available water capacity and high salt content (fig. 13). The main concerns in management are maintaining tilth and the level of fertility, removing excess water, and preventing soil blowing. Capability unit IIIs-P4. Fargo soil in Clayey range site and windbreak suitability group 1, Ryan soil in Thin Claypan range site and windbreak suitability group 9.

Figure 13.—**Uneven growth of alfalfa on Fargo-Ryan silty clays. The thin stand is in light-colored areas of Ryan soil.**

Fordville Series

The Fordville series consists of moderately deep, well-drained, nearly level to sloping soils on beach ridges and outwash plains. These soils formed in medium-textured alluvium underlain by coarse sand and gravel.

In a representative profile the surface layer is black loam about 9 inches thick. The subsoil is very dark grayish-brown friable loam about 15 inches thick. The underlying material is dark grayish-brown coarse sand and gravel.

Permeability is moderate in the surface layer and subsoil and very rapid in the underlying material. The available water capacity is low or moderate. The organic-matter content is high, and fertility is medium. Runoff is slow.

Fordville soils are suitable for farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Fordville loam in an area of Fordville-Renshaw loams in a cultivated field, 825 feet east and 1,155 feet south of the northwest corner of sec. 34, T. 130 N., R. 50 N.

Ap—0 to 9 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; weak, fine, granular structure; friable; slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

B2—9 to 24 inches, very dark grayish-brown (10YR 3/2) loam; dark grayish brown (10YR 4/2) when dry; moderate, medium, prismatic structure; friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

IIC—24 to 60 inches, dark grayish-brown (10YR 4/2) coarse sand and gravel; grayish brown (10YR 5/2) when dry; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is black or very dark gray and is 6 to 10 inches thick. The B horizon is very dark brown, dark-brown, very dark grayish-brown, or dark grayish-brown loam or light clay loam 9 to 16 inches thick. The depth to sand and gravel ranges from 20 to 36 inches. In some places a loam C horizon is above the sand and gravel substratum.

Fordville soils are associated with Renshaw soils, and they formed in the same kind of materials as Sioux and Arvilla soils. They have a thicker solum over sand and gravel than Renshaw and Sioux soils. They contain more clay and less sand in the B horizon than Arvilla soils.

Fordville-Renshaw loams (0 to 6 percent slopes) (Ft).—This mapping unit is on low, narrow beach ridges on the lake plain and in small areas of outwash on the till plain. It is about 80 percent Fordville loam and about 20 percent Renshaw loam. Areas are small in size and irregular in shape. Included in mapping are small areas of Sioux soils.

The Fordville and Renshaw soils in this mapping unit have the profiles described as representative of their respective series. The Fordville soil is underlain by coarse sand and gravel at a depth of 20 to 36 inches, and the Renshaw soil has a coarse sand and gravel substratum at a depth of 10 to 20 inches.

The Fordville soil is well drained, and the Renshaw soil is somewhat excessively drained. Available water capacity is moderate to low in the Fordville soil and low in the Renshaw soil. Both soils are moderately susceptible to soil blowing.

These soils are suited to farming, and most areas are used for crops. The main concerns of management are conserving water, preventing soil blowing, and maintaining fertility. Capability unit IIIs-5. Fordville soil in Silty range site and windbreak suitability group 3, Renshaw soil in Shallow to Gravel range site and windbreak suitability group 6.

Forman Series

The Forman series consists of deep, well-drained, nearly level to rolling soils on the glacial till plain. These soils formed in moderately fine textured glacial till.

In a representative profile the surface layer is black loam about 7 inches thick. The subsoil is dark grayish-brown firm clay loam about 8 inches thick. The underlying material is light olive-brown clay loam.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is medium.

Forman soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops. Some are used for hay and pasture.

Representative profile of Forman loam in an area of Forman-Aastad loams, undulating, in a cultivated field, 95 feet south and 2,525 feet east of the northwest corner of sec. 3, T. 129 N., R. 50 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; moderate, coarse, subangular blocky structure parting to moderate, fine, granular; friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

B2t—7 to 15 inches, dark grayish-brown (10YR 4/2) clay loam; grayish brown (10YR 5/2) when dry; moderate, medium, prismatic structure parting to moderate, medium and fine, angular blocky; firm, sticky and plastic; thin continuous clay films on faces of all peds; neutral; clear, wavy boundary.

C1ca—15 to 32 inches, light olive-brown (2.5Y 5/4) clay loam; light yellowish brown (2.5Y 6/3) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; violent effervescence; common soft lime masses; mildly alkaline; gradual, wavy boundary.

C2—32 to 60 inches, light olive-brown (2.5Y 5/4) clay loam; light yellowish brown (2.5Y 6/3) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The solum ranges from 12 to 26 inches in thickness. The A horizon is black or very dark gray loam or clay loam 4 to 8 inches thick. The B horizon is very dark grayish brown, dark grayish brown, dark brown, or brown. The depth to the Cca horizon ranges from 12 to 26 inches. The C horizon is loam or clay loam.

Forman soils are associated with Aastad, Buse, and Peever soils, and they are similar to Barnes soils. They are dark colored to a lesser depth and are better drained than Aastad soils. They have a thicker solum than Buse soils. They contain less clay in the B horizon than Peever soils. They contain more clay in the B horizon than Barnes soils.

Forman-Aastad loams, undulating (3 to 6 percent slopes) (FuB).—This mapping unit is on the glacial till plain. It is about 60 percent Forman loam and about 40 percent Aastad loam. The Forman soil is on the crests and upper parts of low knolls and ridges, and the Aastad soil is on lower parts. Areas are small to large in size and irregular in shape. Included in mapping are small areas of poorly drained Tonka and Parnell soils in shallow depressions. The Forman soil in this mapping unit has the profile described as representative of the series.

The Forman soil is well drained, and the Aastad soil is moderately well drained. Permeability in these soils is moderate in the surface layer and subsoil and moderately slow in the underlying material. Runoff is medium, and the hazard of erosion is moderate.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility, conserving water, and preventing erosion. Capability unit IIe-6. Forman soil in Silty range site and windbreak suitability group 3, Aastad soil in Overflow range site and windbreak suitability group 1.

Forman-Aastad loams, undulating, eroded (3 to 6 percent slopes) (FuB2).—This mapping unit is on the glacial till plain. It is about 70 percent Forman loam and about 30 percent Aastad loam. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of poorly drained Parnell and Tonka soils in shallow depressions.

The Forman soil in this mapping unit has a profile similar to that described as representative of the series, but the surface layer is several inches thinner. This soil is on the crests and upper parts of small knolls where most of the erosion in this mapping unit has occurred. The Aastad soil is on the lower parts.

The Forman soil is well drained, and the Aastad soil is moderately well drained. The surface layer and subsoil of these soils are moderately permeable, and the underlying material has moderately slow permeability. Runoff is medium, and the hazard of erosion is moderate.

These soils are well suited to farming, and all of the acreage is used for crops. The main concerns of management are preventing erosion, conserving water, and improving and maintaining fertility. Capability unit IIe-6. Forman soil in Silty range site and windbreak suitability group 3, Aastad soil in Overflow range site and windbreak suitability group 1.

Forman-Buse loams, rolling (6 to 9 percent slopes) (FvC).—This mapping unit is on low knolls and ridges on the glacial till plain. It is about 70 percent Forman loam and about 30 percent Buse loam. The Forman soil is on hillsides, and the Buse soil is on hilltops. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Aastad soils.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. Runoff is medium, and the hazard of erosion is severe.

These soils are suited to farming, and most areas are used for crops. Because erosion is a hazard, the soils are better suited to small grain and tame grasses and legumes than to row crops. The main concerns of management are preventing erosion, conserving moisture, and maintaining fertility. Capability unit IIIe-6. Forman soil in Silty range site and windbreak suitability group 3, Buse soil in Thin Upland range site and windbreak suitability group 8.

Forman-Buse loams, rolling, eroded (6 to 9 percent slopes) (FvC2).—This mapping unit is on low knolls and ridges on the glacial till plain. It is about 70 percent Forman loam and about 30 percent Buse loam. The Forman soil is on the hillsides, and the Buse soil is on the eroded hilltops. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Aastad soils.

The Forman and Buse soils in this mapping unit have profiles similar to those described as representative of their respective series, but the surface layer is several inches thinner. If plowed, the dark grayish-brown subsoil of the Forman soil and the light-colored, calcareous underlying material of the Buse soil are exposed in many places.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. Runoff is medium, and the hazard of erosion is severe.

These soils are suited to farming, and all areas are used for crops. Because of the hazard of erosion, the soils are better suited to small grain and tame grasses and legumes than to row crops. The main concerns of management are preventing further erosion, conserving water, and improving and maintaining fertility. Capability unit IIIe-6. Forman soil in Silty range site and windbreak suitability group 3, Buse soil in Thin Upland range site and windbreak suitability group 8.

Forman-Peever clay loams, undulating (3 to 6 percent slopes) (FwB).—This mapping unit of well-drained soils is on the glacial till plain. It is about 50 percent Forman clay loam and about 35 percent Peever clay loam. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of moderately well drained Aastad soils and poorly drained Tonka and Parnell soils.

The Forman soil in this mapping unit has a profile similar to that described as representative of the series, but the surface layer is clay loam. The Peever soil has the profile described as representative of the series.

Runoff is medium on these soils, and the hazard of erosion is moderate. Permeability of the Forman soil is moderate in the surface layer and subsoil and moderately slow in the underlying material. Permeability of the Peever soil is slow in the subsoil and moderately slow in the underlying material.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility, conserving water, and preventing erosion. Capability unit IIe-6. Forman soil in Silty range site and windbreak suitability group 3, Peever soil in Clayey range site and windbreak suitability group 4.

Fossum Series

The Fossum series consists of deep, poorly drained, level soils on flats and in slight depressions in the Sheyenne Delta and the lake plain. These soils formed in coarse-textured lacustrine sediments.

In a representative profile the surface layer is loam about 12 inches thick. The upper part is black, and the lower part is very dark gray. The underlying material, to a depth of 60 inches, is fine sand. The upper part is grayish brown and the lower part is olive gray mottled with light olive brown and dark yellowish brown.

Permeability is rapid, and the available water capacity is low or moderate. The organic-matter content is high, and fertility is medium. Runoff is very slow. The water table is near the surface in spring and during periods of heavy rainfall.

Fossum soils are suited to farming if excess water is removed. They are well suited to hay and pasture. Limitations for many nonfarm uses are severe. Most areas of these soils are used for hay and pasture. Some areas are used for crops.

Representative profile of Fossum loam in an area of Arveson and Fossum loams in a native pasture, 300 feet north and 1,060 feet west of the southeast corner of sec. 4, T. 134 N., R. 53 W.

A11—0 to 7 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; moderate, medium, granular structure; very friable; mildly alkaline; strong effervescence; clear, smooth boundary.

A12ca—7 to 12 inches, very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) when dry; weak, medium and fine, granular structure; very friable; mildly alkaline; strong effervescence; abrupt, smooth boundary.

C1g—12 to 24 inches, grayish-brown (2.5Y 5/2) fine sand; light brownish gray (2.5Y 6/2) when dry; single grained; loose; mildly alkaline; slight effervescence; gradual, wavy boundary.

C2g—24 to 46 inches, olive-gray (5Y 5/2) fine sandy; light olive gray (5Y 6/2) when dry; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles; single grained, loose; mildly alkaline; slight effervescence; gradual, wavy boundary.

C3g—46 to 60 inches, olive-gray (5Y 5/2) fine sand; light olive gray (5Y 6/2) when dry; many, coarse, prominent, dark yellowish-brown (10YR 4/4) mottles; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is loam or fine sandy loam 10 to 16 inches thick. There is a slight accumulation of lime in the lower part of the A horizon or in the upper part of the C horizon. The C horizon is loamy fine sand or fine sand.

Fossum soils are associated with Arveson soils, and they formed in the same kind of material as Ulen soils. They contain less lime than Arveson soils. They are more poorly drained than Ulen soils.

Fossum fine sandy loam (0 to 1 percent slopes) (Fx).—This soil is in shallow depressions and on broad flats on the Sheyenne Delta. It has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam. Areas are small to medium in size and are irregular in shape. Included in mapping are small areas of Hamar, Ulen, and Arveson soils.

This soil is poorly drained. The water table is at or

near the surface in spring and during periods of heavy rainfall. Permeability is rapid. If this soil is cultivated and the surface layer is left bare and dry, the hazard of soil blowing is severe.

This soil is well suited to pasture and hay. It is suited to crops if excess water is removed. The main concerns of management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIIwe-3; Wet Meadow range site; windbreak suitability group 2.

Galchutt Series

The Galchutt series consists of deep, somewhat poorly drained, nearly level soils on the lake plain. These soils are plane and slightly concave. They formed in medium-textured lacustrine sediments and the underlying fine-textured lacustrine sediments.

In a representative profile the surface layer is black silt loam about 16 inches thick. The subsurface layer is very dark grayish-brown and olive-brown silt loam about 9 inches thick. The subsoil is firm clay about 12 inches thick. The upper part is olive brown, and the lower part is dark grayish brown. The underlying material is gray and olive-brown clay mottled with light yellowish brown.

Permeability is moderate in the surface layer and subsurface layer and slow in the subsoil and underlying material. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow.

Galchutt soils are well suited to farming if excess water is removed. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Galchutt silt loam in an area of Galchutt-Enloe-Fargo complex in a cultivated field, 175 feet west and 1,875 feet south of the northeast corner of sec. 13, T. 132 N., R. 49 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; weak, coarse and medium, subangular blocky structure; very friable, slightly sticky and slightly plastic; slightly acid; abrupt, smooth boundary.

A12—8 to 16 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; weak, coarse, prismatic structure parting to weak, thin, platy; very friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

A2—16 to 25 inches, very dark grayish-brown (2.5Y 3/2) and olive-brown (2.5Y 4/3) silt loam; grayish brown (2.5Y 5/2) and light yellowish brown (2.5Y 6/3) when dry; few, fine, faint, dark-brown (10YR 4/3) mottles; weak, very coarse, prismatic structure parting to weak, thin, platy; very friable, slightly sticky and slightly plastic; neutral; abrupt, wavy boundary.

IIB21t—25 to 32 inches, olive-brown (2.5Y 4/3) clay; light yellowish brown (2.5Y 6/3) when dry; few, fine, gray (5Y 5/1) mottles; weak, coarse, prismatic structure parting to strong, fine, angular blocky; firm, sticky and plastic; neutral; gradual, wavy boundary.

IIB22t—32 to 37 inches, dark grayish-brown (2.5Y 4/2) clay; light brownish gray (2.5Y 6/2) when dry; common, medium, distinct, dark-gray (5Y 4/1) and common, fine, faint, olive-brown (2.5Y 4/4) mottles; weak, coarse, prismatic structure parting to strong, fine, angular blocky; firm, sticky and plastic; mildly alkaline; slight effervescence; gradual, wavy boundary.

IIC—37 to 60 inches, multicolored gray (5Y 5/1) and olive-brown (2.5Y 4/3) clay; gray (5Y 6/1) when dry; common, medium and fine, distinct, light yellowish-brown (2.5Y 6/4) mottles; massive; firm, sticky and plastic; few lime spots; mildly alkaline; slight effervescence.

The A1 horizon is silt loam or silty clay loam 10 to 20 inches thick. The A2 horizon is very fine sandy loam, silt loam, or silty clay loam 4 to 14 inches thick. It is very dark gray, dark gray, very dark grayish brown, dark grayish brown, or olive brown. The IIB horizon is dark grayish-brown, grayish-brown, olive-brown, light olive-brown, olive-gray, or olive silty clay or clay. The depth to the IIB horizon ranges from 16 to 34 inches. The IIC horizon is silty clay or clay.

Galchutt soils are associated with Aberdeen, Enloe, Fargo, and Overly soils. They have thicker A1 and A2 horizons than Aberdeen soils, and they contain less sodium and magnesium salts in the B horizon. They are better drained than Enloe soils and have less clay in the A1 and A2 horizons. They differ from Fargo and Overly soils in having an A2 horizon. They are better drained than Fargo soils and more poorly drained than Overly soils.

Galchutt silt loam (0 to 1 percent slopes) (Ga).—This soil is on the lake plain on broad flats that are small to medium in size and irregular in shape. Included in mapping are small areas of Enloe soils.

This Galchutt soil is somewhat poorly drained. The water table is within 1 to 3 feet of the surface in spring and during periods of heavy rainfall. Permeability is moderate in the surface layer and subsurface layer and slow in the subsoil and underlying material. Runoff is very slow, and the hazard of erosion is slight.

This soil is well suited to farming, and most areas are used for crops. The main concerns of management are removing excess water and maintaining fertility. Capability unit IIw-6; Silty range site; windbreak suitability group 1.

Galchutt-Enloe-Fargo complex (0 to 1 percent slopes) (Gc).—This mapping unit is on the lake plain in broad flats that are medium to large in size and irregular in shape. It is about 50 percent Galchutt silt loam, about 30 percent Enloe silty clay loam, and about 20 percent Fargo silty clay loam.

The Galchutt soil in this mapping unit has the profile described as representative of the series. The Fargo soil has a profile similar to that described as representative of the series, but the surface layer is silty clay loam.

The Galchutt soil is somewhat poorly drained, and the Fargo and Enloe soils are poorly drained. Runoff is very slow, and in some areas these soils are ponded early in spring and during periods of heavy rainfall. Permeability in the Galchutt soil is moderate in the surface layer and subsurface layer and slow in the subsoil and underlying material. The Enloe and Fargo soils have slow permeability. The hazard of erosion is slight.

These soils are well suited to farming if excess water is removed. Most areas are used for crops. The main concerns of management are removing excess water and maintaining fertility. Capability unit IIw-6. Galchutt soil in Silty range site and windbreak suitability group 1, Enloe soil in Wet Meadow range site and windbreak suitability group 2, Fargo soil in Clayey range site and windbreak suitability group 1.

Figure 14.—**Profile of Gardena silt loam.**

Galchutt-Overly silt loams (0 to 3 percent slopes) (Gd).—This mapping unit is in broad flats on the lake plain. It is about 70 percent Galchutt silt loam and about 30 percent Overly silt loam. Areas are small to large in size and irregular in shape.

The Overly soil has a profile similar to that described as representative of the series, but the surface layer and subsoil are silt loam, and the underlying material, which is below a depth of about 30 to 40 inches, is silty clay or clay.

The Galchutt soil is somewhat poorly drained, and the Overly soil is moderately well drained. Some areas of these soils have a high water table in spring and during periods of heavy rainfall, but it does not interfere with tillage. Permeability is moderate in the silty upper part of these soils and slow in the clay subsoil and substratum. Runoff is slow, and the hazard of erosion is slight.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility and conserving water. Capability unit IIc-6; Silty range site; windbreak suitability group 1.

Gardena Series

The Gardena series consists of deep, moderately well drained, nearly level to undulating soils on the lake plain. These soils formed in medium-textured lacustrine sediments.

In a representative profile (fig. 14) the surface layer is black silt loam about 12 inches thick. The subsoil is very dark grayish-brown friable silt loam about 6 inches thick. The underlying material, to a depth of 60 inches, is light olive-brown silt loam mottled in the lower part with yellowish brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high. Fertility is high.

Gardena soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Gardena silt loam in a cultivated field, 150 feet south and 90 feet east of the northwest corner of sec. 20, T. 132 N., R. 51 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; weak, medium, crumb structure; very friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; weak, coarse, subangular blocky structure parting to weak, medium, crumb; very friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

B2—12 to 18 inches, very dark grayish-brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) when dry; moderate, medium, prismatic structure parting to moderate, fine, subangular blocky; friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

C1ca—18 to 32 inches, light olive-brown (2.5Y 5/3) silt loam; pale yellow (2.5Y 7/3) when dry; weak, medium, subangular blocky structure; very friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2—32 to 42 inches, light olive-brown (2.5Y 5/4) silt loam; pale yellow (2.5Y 7/4) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C3—42 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; pale yellow (2.5Y 7/4) when dry; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable,

slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The solum ranges from 16 to 30 inches in thickness. The A horizon is very dark gray or black loam, very fine sandy loam, or silt loam 8 to 14 inches thick. The B horizon is very dark grayish brown, dark grayish brown, very dark brown, or dark brown. The C horizon is silt loam, loam, or very fine sandy loam. In some places the lower part of the C horizon, below a depth of 40 inches, is silty clay or fine sandy loam.

Gardena soils are associated with Eckman, Embden, and Svea soils. They are dark colored to a greater depth and are not so well drained as Eckman soils. They are finer textured than Embden soils. They contain less clay and fewer coarse fragments than Svea soils.

Gardena silt loam (0 to 3 percent slopes) (Ge).—This soil is on the lake plain in broad flats that are small to large in size and irregular in shape. Included in mapping are small areas of Glyndon and Tiffany soils and areas where the surface layer is very fine sandy loam. This Gardena soil has the profile described as representative of the series.

This soil is moderately well drained. Permeability is moderate. Runoff is slow. The hazard of soil blowing is moderate.

This soil is well suited to farming, and most areas are used for crops. The main concerns of management are conserving water, preventing soil blowing, and maintaining fertility. Capability unit IIe-5; Silty range site; windbreak suitability group 1.

Gardena-Eckman silt loams, undulating (3 to 6 percent slopes) (GfB).—This mapping unit is on low knolls and side slopes on the lake plain. It is about 65 percent Gardena silt loam and about 35 percent Eckman silt loam. The Gardena soil is on the lower slopes, and the Eckman soil is on the hilltops and upper slopes. Areas are small to medium in size and irregular in shape.

The Gardena soil in this mapping unit has a profile similar to that described as representative of the series, but in some places the surface layer is several inches thinner. The Eckman soil has the profile described as representative of the Eckman series.

Permeability is moderate in both soils. Runoff is medium, and the hazards of soil blowing and erosion are moderate.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are conserving moisture, preventing erosion, and maintaining fertility. Capability unit IIe-5; Silty range site; Gardena soil in windbreak suitability group 1, Eckman soil in windbreak suitability group 3.

Gardena and Embden loams (0 to 3 percent slopes) (Gh).—This mapping unit is on the lake plain and the Sheyenne Delta. Some areas of this unit are Gardena loam, some are Embden loam, and some areas are both. Areas are small to medium in size and irregular in shape.

The Gardena soil in this mapping unit has a profile similar to that described as representative of the series, but the surface layer is loam and the underlying material, below a depth of 30 to 40 inches, is fine sandy loam. The Embden soil has a profile similar to that described as representative of the series, but the surface layer is loam.

These soils are moderately well drained. Runoff is slow. Permeability is moderate in the Gardena soil and moderately rapid in the Embden soil. The hazard of soil blowing is moderate.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are conserving water, preventing soil blowing, and maintaining fertility. Capability unit IIe-5. Gardena soil in Silty range site and windbreak suitability group 1, Embden soil in Sandy range site and windbreak suitability group 1.

Gilby Series

The Gilby series consists of deep, somewhat poorly drained, nearly level soils on the lake plain. These soils have a zone of lime accumulation within 16 inches of the surface. They formed in medium-textured lacustrine sediments and the underlying moderately fine textured glacial till.

In a representative profile the surface layer is black silt loam about 8 inches thick. The underlying material, to a depth of about 26 inches, is very fine sandy loam. The upper part is dark grayish brown and strongly calcareous. The lower part is light olive brown. Below this is olive-gray clay loam mottled with yellowish brown.

Permeability is moderate in the upper part of the profile and moderately slow in the clay loam till substratum. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow.

Gilby soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Gilby silt loam in a cultivated field, 1,320 feet south and 180 feet east of the northwest corner of sec. 21, T. 130 N., R. 48 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; very dark gray (10YR 3/1) when dry; weak, coarse, subangular blocky structure parting to moderate, fine, granular; friable, slightly sticky and slightly plastic; neutral; slight effervescence; abrupt, smooth boundary.

C1ca—8 to 17 inches, dark grayish-brown (2.5Y 4/2) very fine sandy loam; grayish brown (2.5Y 5/2) when dry; weak, coarse, subangular blocky structure; very friable; mildly alkaline; violent effervescence; clear, wavy boundary.

C2—17 to 26 inches, light olive-brown (2.5Y 5/3) very fine sandy loam; light yellowish brown (2.5Y 6/3) when dry; few, fine, distinct, very dark brown (10YR 2/2) mottles; weak, coarse, subangular blocky structure; very friable; neutral; slight effervescence; clear, wavy boundary.

IIC3g—26 to 60 inches, olive-gray (5Y 5/2) clay loam; light gray (5Y 7/2) when dry; many, coarse, prominent, yellowish-brown (10YR 5/6) mottles; massive; firm, sticky and plastic; mildly alkaline; strong effervescence; common lime masses and few gypsum crystals.

The A horizon is loam or silt loam 7 to 15 inches thick. The C horizon is loam, silt loam, or very fine sandy loam. Depth to the IIC horizon ranges from 20 to 36 inches.

Gilby soils are associated with Hamerly soils, and they are closely related to Antler soils. They differ from Hamerly soils in having mottles within 20 inches of the surface. They contain less clay in the upper part of the profile than Antler soils.

Gilby silt loam (0 to 3 percent slopes) (Gk).—This soil is on the lake plain in broad flats that are medium to

large in size and irregular in shape. Included in mapping are small areas of Tiffany soils. This Gilby soil has the profile described as representative of the series.

This soil is somewhat poorly drained. Runoff is slow. Permeability is moderate in the upper part of the profile and moderately slow in the clay loam underlying material. The water table is near the surface early in spring and during periods of heavy rainfall, but it seldom interferes with tillage. The hazard of soil blowing is moderate.

This soil is well suited to farming, and nearly all areas are used for crops. The main concerns of management are preventing soil blowing and maintaining fertility. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Gilby silt loam, moderately saline (0 to 3 percent slopes) (Gm).—This soil is on the lake plain in interbeach areas that are small in size and irregular in shape. This soil has a profile similar to that described as representative of the series, but the surface layer contains a moderate amount of salts.

This soil is somewhat poorly drained. Runoff is slow. Permeability is moderate in the upper part of the profile and moderately slow in the clay loam underlying material. The water table is near the surface early in spring and during periods of heavy rainfall, but it seldom interferes with tillage. The hazard of soil blowing is moderate.

This soil is suitable for farming, and nearly all the acreage is used for crops. Because of the salt content, crops do not grow so well on this soil as on Gilby silt loam. The main concerns of management are reducing salinity, preventing erosion, and improving and maintaining fertility. Capability unit IIIs-4L; Subirrigated range site; windbreak suitability group 10.

Gilby and Hamerly loams (0 to 3 percent slopes) (Gn). —This mapping unit is on the lake plain where a thin mantle of lacustrine sediments overlie glacial till. Some areas are Gilby loam, some are Hamerly loam, and some areas are both. Areas are small in size and irregular in shape. The Gilby soil has a profile similar to that described as representative of the series, but the surface layer is loam.

Gilby and Hamerly soils are somewhat poorly drained. Permeability is moderate in the upper part of the profile and moderately slow in the underlying material. Runoff is slow. The water table is near the surface in spring and during periods of heavy rainfall, but it does not interfere with tillage. The hazard of soil blowing is moderate.

These soils are suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility, conserving water, and preventing soil blowing. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Glyndon Series

The Glyndon series consists of deep, somewhat poorly drained, nearly level soils on the lake plain and the Sheyenne Delta. These soils are plane and slightly convex. They have a zone of lime accumulation within 16 inches of the surface. They formed in medium-textured lacustrine sediments.

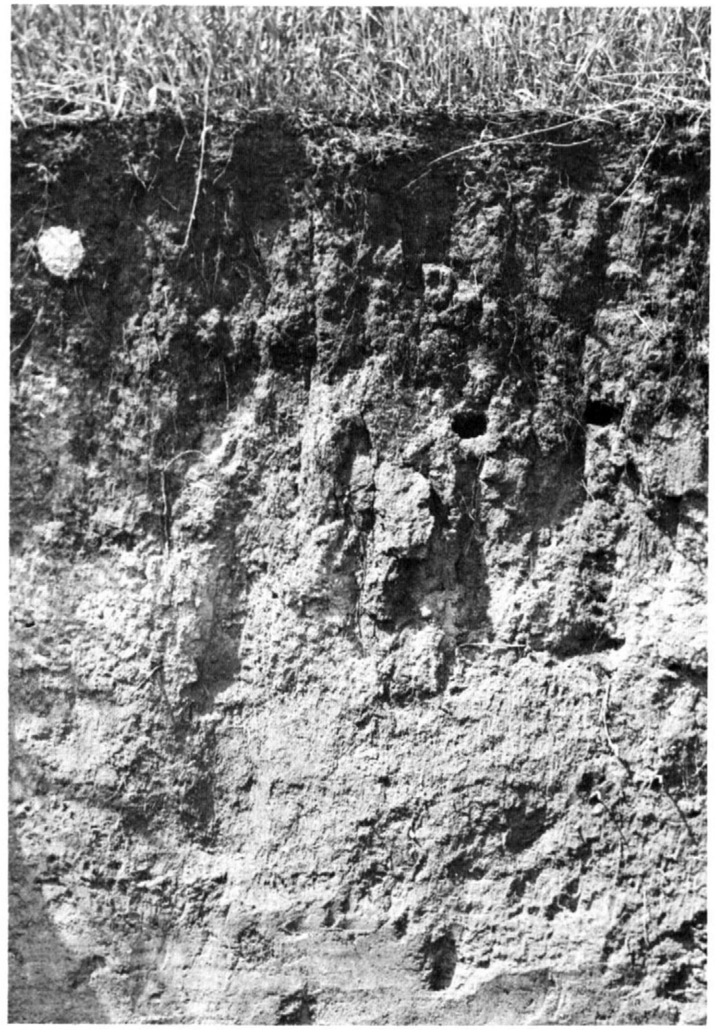

***Figure 15.*—Profile of Glyndon silt loam showing dark-colored surface layer and light-gray lime zone.**

In a representative profile (fig. 15) the surface layer is silt loam about 15 inches thick. The upper part is black, and the lower part is very dark gray. The underlying material, to a depth of about 22 inches, is grayish-brown silt loam that contains a large amount of lime. The next layer is light olive-brown silt loam about 20 inches thick. Below this is light olive-brown very fine sandy loam mottled with yellowish brown and dark yellowish brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow. In some areas Glyndon soils are underlain by clay or silty clay below a depth of 36 inches. Permeability in these soils is moderate in the upper part of the profile and slow in the clayey substratum.

Glyndon soils are suited to farming. Limitations for many nonfarm uses are moderate to severe. Most areas are used for crops.

Representative profile of Glyndon silt loam in a cultivated field, 925 feet west and 2,500 feet north of the southeast corner of sec. 11, T. 132 N., R. 51 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; neutral; slight effervescence; abrupt, smooth boundary.

A12ca—8 to 15 inches, very dark gray (10YR 3/1) silt loam; gray (10YR 5/1) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; clear, smooth boundary.

C1ca—15 to 22 inches, grayish-brown (2.5Y 5/2) silt loam; light gray (2.5Y 7/2) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; moderately alkaline; violent effervescence; clear, irregular boundary.

C2—22 to 42 inches, light olive-brown (2.5Y 5/4) silt loam; light yellowish brown (2.5Y 6/4) when dry; weak, medium, subangular blocky structure; very friable; mildly alkaline; strong effervescence; gradual, wavy boundary.

C3—42 to 60 inches, light olive-brown (2.5Y 5/4) very fine sandy loam; light yellowish brown (2.5Y 6/4) when dry; common, medium, prominent yellowish-brown (10YR 5/8) and dark yellowish-brown (10YR 4/4) mottles; very friable; mildly alkaline; slight effervescence.

The A horizon is silt loam, very fine sandy loam, or loam 7 to 15 inches thick. The C horizon is very fine sand, loamy very fine sand, very fine sandy loam, or silt loam. In some places there is a IIC horizon below a depth of about 36 inches that ranges from fine sand to clay.

Glyndon soils are associated with Bearden, Tiffany, and Wyndmere soils, and they formed in the same kind of material as Borup soils. They contain less clay than Bearden soils. They differ from Tiffany soils in having a Cca horizon. They are better drained and have fewer mottles in the upper part of the C horizon than Borup soils. They contain less fine and coarse sand than Wyndmere soils.

Glyndon silt loam (0 to 3 percent slopes) (Go).—This soil is on the lake plain and the Sheyenne Delta in broad flats that are small to large in size and irregular in shape. Included in mapping are small areas of Gardena and Tiffany soils. This Glyndon soil has the profile described as representative of the series.

This soil is somewhat poorly drained. Runoff is slow. Permeability is moderate. The water table is near the surface in spring and during periods of heavy rainfall, but it does not interfere with tillage. The hazard of soil blowing is moderate.

This soil is well suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility, conserving water, and preventing soil blowing. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Glyndon and Wyndmere loams (0 to 3 percent slopes) (Gu).—This mapping unit is on the lake plain and the Sheyenne Delta in broad flats that are small to medium in size and irregular in shape. Some areas are Glyndon loam, some are Wyndmere loam, and some are both.

The Glyndon soil in this mapping unit has a profile similar to that described as representative of the series, but the underlying material below a depth of about 30 inches is fine sandy loam, loamy fine sand, or fine sand. The Wyndmere soil has a profile similar to that described as representative of the series, but the surface layer is loam.

These soils are somewhat poorly drained. Runoff is slow. Permeability is moderate in the Glyndon soil and moderately rapid in the Wyndmere soil. The hazard of soil blowing is moderate.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIe-4L. Glyndon soil in Silty range site and windbreak suitability group 1, Wyndmere soil in Sandy range site and windbreak suitability group 1.

Glyndon-Tiffany very fine sandy loams (0 to 3 percent slopes) (Gr).—This mapping unit is on the Sheyenne Delta in broad flats that are small to large in size and irregular in shape. It is about 65 percent Glyndon very fine sandy loam, about 20 percent Tiffany very fine sandy loam, and 15 percent small areas of Arveson, Borup, and Wyndmere soils.

The Glyndon and Tiffany soils have profiles similar to those described as representative of their respective series, but the surface layer is very fine sandy loam.

The Glyndon soil is somewhat poorly drained, and the Tiffany soil is poorly drained. Permeability is moderate in the Glyndon soil and moderately rapid in the Tiffany soil. Runoff is slow. The water table is near the surface in spring and during periods of heavy rainfall. The hazard of soil blowing is moderate.

These soils are suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility, preventing soil blowing, and removing excess water from some areas of the Tiffany soil. Capability unit IIe-4L. Glyndon soil in Silty range site and windbreak suitability group 1, Tiffany soil in Subirrigated range site and windbreak suitability group 2.

Glyndon-Tiffany loams, moderately deep over clay (Gt).—This mapping unit is on the lake plain and the Sheyenne Delta in broad flats that are small to large in size and irregular in shape. It is about 60 percent Glyndon loam, moderately deep over clay, and about 30 percent Tiffany loam, moderately deep over clay. Included in mapping are small areas of Galchutt soils.

The Glyndon soil in this mapping unit has a profile similar to that described as representative of the series, but the surface layer is loam and the underlying material below a depth of about 36 inches is silty clay or clay. The Tiffany soil has a profile similar to that described as representative of its series, but the underlying material below a depth of about 24 to 36 inches is silty clay or clay.

The Glyndon soil is somewhat poorly drained, and the Tiffany soil is poorly drained. Permeability is moderate in the upper part of the Glyndon soil and slow in the clay substratum. It is moderately rapid in the upper part of the Tiffany soil and slow in the clay substratum. Runoff is slow. The water table is near the surface in spring and during periods of heavy rainfall. Some areas of Tiffany soils are occasionally ponded. Soil blowing is a moderate hazard.

These soils are suited to farming, and most areas are used for crops. The main concerns of management are preventing soil blowing, maintaining fertility, and removing excess water on Tiffany soil. Capability unit

IIe-4L. Glyndon soil in Silty range site and windbreak suitability group 1, Tiffany soil in Subirrigated range site and windbreak suitability group 2.

Grano Series

The Grano series consists of deep, very poorly drained, level, calcareous, fine-textured soils in shallow and deep depressions on the lake plain. These soils formed in fine-textured lacustrine sediments.

In a representative profile the surface layer is clay about 16 inches thick. The upper part is black, and the lower part is very dark gray. The underlying material, to a depth of 26 inches, is dark-gray clay that contains a large amount of lime. Below this is olive-gray clay mottled with olive brown and yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow. The water table is at the surface or within a depth of 3 feet. The soils are frequently ponded.

Grano soils are suited to cultivated crops if excess water is removed. Undrained, they are better suited to hay or pasture than to most other uses. Limitations for many nonfarm uses are severe.

Representative profile of Grano clay in a cultivated field, 160 feet south and 800 feet east of the northwest corner of sec. 8, T. 129 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) clay; very dark gray (10YR 3/1) when dry; moderate, medium, subangular blocky structure; firm, very sticky and very plastic; neutral; slight effervescence; abrupt, smooth boundary.

A12—7 to 16 inches, very dark gray (10YR 3/1) clay; dark gray (10YR 4/1) when dry; strong, fine, angular blocky structure; firm, very sticky and very plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

C1cag—16 to 26 inches, dark-gray (5Y 4/1) clay; gray (5Y 5/1) when dry; strong, medium and fine, angular blocky structure; firm, very sticky and very plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2g—26 to 42 inches, olive-gray (5Y 5/2) clay; light olive gray (5Y 6/2) when dry; common, medium, distinct, olive-brown (2.5Y 4/4) mottles; strong, fine, angular blocky structure; firm, very sticky and very plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C3g—42 to 60 inches, olive-gray (5Y 5/2) clay; light olive gray (5Y 6/2) when dry; many, medium, distinct, olive-brown (2.5Y 4/4) and common, medium, prominent, dark yellowish-brown (10YR 4/4) mottles; massive; firm, very sticky and very plastic; mildly alkaline; strong effervescence.

The A horizon is silty clay or clay 8 to 24 inches thick. The C horizon is dark gray, olive gray, or olive silty clay or clay. In some places the lower part of the C horizon, below a depth of 48 inches, is clay loam glacial till.

Grano soils formed in the same kind of material as Dovray and Hegne soils. They are dark colored to a lesser depth and they contain more lime in the A horizon than Dovray soils. They contain less lime in the upper 16 inches than Hegne soils.

Grano clay (0 to 1 percent slopes) (Gw).—This soil is on the lake plain in shallow and deep depressions that are small to medium in size and are irregular in shape. Included in mapping are small areas of Dovray and Hegne soils.

This Grano soil is very poorly drained, and it is frequently ponded in spring and during periods of heavy rainfall. Permeability is slow. The soil is difficult to work and keep in good tilth.

Some areas of this soil have been drained and are used for crops. Undrained areas are used mainly for hay and pasture. This soil is suited to farming if excess water is removed and tilth is maintained. Otherwise, it is better suited to hay and pasture than to most other uses. The main concerns of management are removing excess water and maintaining tilth and fertility. Capability unit IIIw-4; Wetland range site; windbreak suitability group 2.

Hamar Series

The Hamar series consists of deep, somewhat poorly drained or poorly drained, nearly level soils on flats and in shallow depressions on the Sheyenne Delta. These soils formed in coarse-textured lacustrine and eolian deposits.

In a representative profile the surface layer is loamy fine sand about 17 inches thick. The upper part is black, and the lower part is very dark grayish brown mottled with dark yellowish brown. The underlying material, to a depth of 32 inches, is olive-brown loamy fine sand mottled with dark yellowish brown. Below this is grayish-brown loamy fine sand mottled with yellowish brown and dark yellowish brown.

Permeability is rapid, and the available water capacity is low or moderate. The organic-matter content is high, and fertility is medium. Runoff is slow. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. In some areas Hamar soils are underlain by clay or silty clay at a depth of 20 to 36 inches. Permeability in these soils is rapid in the upper part of the profile and slow in the clayey substratum.

Hamar soils are suited to farming. Limitations for many nonfarm uses are severe. Most areas are used for crops. Some are used for pasture and hay.

Representative profile of Hamar loamy fine sand in a cultivated field, 225 feet south and 135 feet east of the northwest corner of sec. 5, T. 135 N., R. 50 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; mildly alkaline; abrupt, smooth boundary.

A12—8 to 17 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; grayish brown (10YR 5/2) when dry; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, subangular blocky structure; very friable; mildly alkaline; gradual, wavy boundary.

C1g—17 to 32 inches, olive-brown (2.5Y 4/3) loamy fine sand; light yellowish brown (2.5Y 6/3) when dry; common, medium, distinct, dark yellowish brown (10YR 4/4) mottles; weak, coarse, subangular blocky structure parting to single grained; very friable; mildly alkaline; gradual, wavy boundary.

C2g—32 to 60 inches, grayish-brown (2.5Y 5/2) loamy fine sand; light gray (2.5Y 7/2) when dry; common, medium, prominent, yellowish-brown (10YR 5/6) and dark yellowish-brown (10YR 4/4) mottles; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is black, very dark gray, very dark brown, or very dark grayish-brown fine sandy loam or loamy fine sand 12 to 24 inches thick. The C horizon is loamy fine sand or fine sand.

Hamar soils are associated with Arveson, Hecla, Maddock, and Ulen soils, and they formed in the same kind of material as Venlo soils. They contain less lime in the upper part of the profile than Arveson and Ulen soils. They are more poorly drained and have more mottles in the upper part of the profile than Hecla and Maddock soils. They are better drained than Venlo soils.

Hamar loamy fine sand (0 to 1 percent slopes) (Ha).—This soil is in shallow depressions and on slightly concave flats on the Sheyenne Delta and the lake plain. It has the profile described as representative of the series. Included in mapping are small areas of Fossum and Ulen soils.

This Hamar soil is poorly drained. Runoff is slow. The water table is near the surface in spring and in periods of heavy rainfall. Permeability is rapid. If the surface is left bare and dry, the hazard of soil blowing is very severe.

This soil is suited to farming if soil blowing is controlled. Most areas are used for crops, but some areas are used for hay and pasture. The main concerns of management are preventing soil blowing, removing excess water, and maintaining fertility. Capability unit IVwe-2; Subirrigated range site; windbreak suitability group 2.

Hamar loamy fine sand, moderately deep over clay (0 to 1 percent slopes) (Hb).—This soil is in shallow depressions and on slightly concave flats on the Sheyenne Delta and the lake plain. It has a profile similar to that described as representative of the series, but the underlying material, below a depth of about 20 to 36 inches, is silty clay or clay. Included in mapping are small areas of Towner soils.

This Hamar soil is poorly drained. Runoff is slow. The water table is near the surface in spring and in periods of heavy rainfall. Permeability is rapid in the upper part of the profile and slow in the clay substratum. If the surface is left bare and dry, the hazard of soil blowing is very severe.

This soil is suited to farming if soil blowing is controlled. Most areas are used for crops, but some are used for hay and pasture. The main concerns of management are preventing soil blowing, removing excess water, and maintaining fertility. Capability unit IVwe-2; Subirrigated range site; windbreak suitability group 2.

Hamar fine sandy loam (0 to 1 percent slopes) (Hc).—This soil is on the Sheyenne Delta and the lake plain in shallow depressions that are small to medium in size and irregular in shape. It has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam. Included in mapping are small areas of Arveson and Ulen soils.

This Hamar soil is poorly drained. Runoff is slow. The water table is near the surface in spring and in periods of heavy rainfall. Permeability is rapid. If the surface layer is left bare and dry, the hazard of soil blowing is severe.

This soil is suited to farming. Most areas are used for crops, but some areas are used for native grass hay and pasture. The main concerns of management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIIwe-3; Subirrigated range site; windbreak suitability group 2.

Hamar fine sandy loam, moderately deep over clay (0 to 1 percent slopes) (He).—This soil is in shallow depressions and on slightly concave flats on the Sheyenne Delta and the lake plain. Areas are small to medium in size and irregular in shape. This soil has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam and the underlying material, below a depth of about 20 to 36 inches, is silty clay or clay. Included in mapping are small areas of Towner soils.

This Hamar soil is poorly drained. Runoff is slow. The water table is near the surface in spring and in periods of heavy rainfall. Permeability is rapid in the upper part of the profile and slow in the clay substratum. If the surface layer is left bare and dry, the hazard of soil blowing is severe.

This soil is suited to farming. Most areas are used for crops, but some areas are in native grass hay and pasture. The main concerns of management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIIwe-3; Subirrigated range site; windbreak suitability group 2.

Hamar-Ulen loamy fine sands (0 to 3 percent slopes) (Hf).—This mapping unit is on the Sheyenne Delta in broad areas that are small to medium in size and irregular in shape. It is about 50 to 85 percent Hamar loamy fine sand and about 15 to 50 percent Ulen loamy fine sand. The Hamar soil is in shallow depressions and slightly concave flats, and the Ulen soil is in slightly higher positions. The Ulen soil has a profile similar to that described as representative of the Ulen series, but the surface layer is loamy fine sand.

The Hamar soil is poorly drained, and the Ulen soil is somewhat poorly drained. Runoff is slow. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Permeability is rapid. If the surface layer is left bare and dry, the hazard of soil blowing is very severe.

These soils are suited to farming if soil blowing is controlled. Most areas are used for crops, but some areas are used for hay and pasture. The main concerns of management are preventing soil blowing, removing excess water, and maintaining fertility. Capability unit IVwe-2. Hamar soil in Subirrigated range site and windbreak suitability group 2, Ulen soil in Sands range site and windbreak suitability group 1.

Hamar-Ulen fine sandy loams (0 to 3 percent slopes) (Hg).—This mapping unit is on the Sheyenne Delta in broad areas that are small to medium in size and irregular in shape. It is about 50 to 85 percent Hamar fine sandy loam and about 15 to 50 percent Ulen fine sandy loam. The Hamar soil is in shallow depressions, and the Ulen soil is in slightly higher positions. The Hamar soil has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam.

The Hamar soil is poorly drained, and the Ulen soil is somewhat poorly drained. Runoff is slow. The water table is within 1 to 3 feet of the surface in spring and in

periods of heavy rainfall. If the surface layer is left bare and dry, the hazard of soil blowing is severe.

These soils are suited to farming. Most areas are used for crops, but some areas are used for hay and pasture. The main concerns of management are preventing soil blowing, removing excess water, and maintaining fertility. Capability unit IIIwe-3. Hamar soil in Subirrigated range site and windbreak suitability group 2, Ulen soil in Sandy range site and windbreak suitability group 1.

Hamerly Series

The Hamerly series consists of deep, somewhat poorly drained, nearly level soils on the till plain and outer edges of the lake plain. These soils are plane and convex and have a zone of lime accumulation within 16 inches of the surface. They formed in medium textured and moderately fine textured glacial till.

In a representative profile the surface layer is black loam about 9 inches thick. The underlying material, to a depth of about 17 inches, is grayish-brown loam that contains a large amount of lime. Below this is light olive-brown loam mottled in the lower part with yellowish brown and light brownish gray.

Permeability is moderate in the upper part of the profile and moderately slow in the underlying material. The available water capacity is high. The organic-matter content is high, and fertility is medium.

Hamerly soils are suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas are used for crops, but some areas are used for pasture and hay.

Representative profile of Hamerly loam in a cultivated field, 170 feet east and 100 feet north of the southwest corner of sec. 17, T. 131 N., R. 51 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; moderate, medium, subangular blocky structure parting to weak, fine, crumb; friable, slightly sticky and slightly plastic; mildly alkaline; slight effervescence; abrupt, smooth boundary.

C1ca—9 to 17 inches, grayish-brown (2.5Y 5/2) loam; gray (2.5Y 6/1) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2—17 to 38 inches, light olive-brown (2.5Y 5/4) loam; light yellowish brown (2.5Y 6/3) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; few gypsum crystals; gradual, wavy boundary.

C3—38 to 60 inches, light olive-brown (2.5Y 5/4) loam; light yellowish brown (2.5Y 6/3) when dry; common, medium, distinct, yellowish-brown (10YR 5/6) and common, medium, faint, light brownish-gray (2.5Y 6/2 mottles; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; common gypsum crystals.

The A horizon is black or very dark gray and is 6 to 15 inches thick. The upper boundary of the Cca horizon is within 16 inches of the surface. The C horizon is loam or clay loam.

Hamerly soils are associated with Gilby soils, and they formed in the same kind of material as Vallers soils. They have fewer mottles in the upper part of the C horizon than Gilby soils. They are better drained than Vallers soils.

Hamerly loam (0 to 3 percent slopes) (Hh).—This soil is on the glacial till plain in areas that are small to large in size and irregular in shape. It has the profile described as representative of the series. Included in mapping are many areas of the poorly drained Tonka soil and the very poorly drained Parnell soil in small depressions and small areas of the moderately well drained Svea soil.

This Hamerly soil is somewhat poorly drained. Runoff is slow. Permeability is moderately slow. The hazard of soil blowing is moderate.

This soil is suited to farming, and most areas are used for crops. The main concerns of management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIe-4L; Silty range site; windbreak suitability group 1.

Hecla Series

The Hecla series consists of deep, moderately well drained, nearly level to undulating soils on the Sheyenne Delta. These soils are plane and convex. They formed in coarse-textured lacustrine and eolian deposits.

In a representative profile the surface layer is fine sandy loam about 16 inches thick. The upper part is black, and the lower part is very dark gray. The next layer is very friable, very dark grayish-brown loamy fine sand 6 inches thick. The underlying material, to a depth of about 32 inches, is dark grayish-brown loamy fine sand. Below this is light olive-brown fine sand mottled with dark brown and yellowish brown.

Permeability is rapid, and the available water capacity is low or moderate. The organic-matter content is high, and fertility is medium. Runoff is slow.

Hecla soils are suited to farming. Limitations for many nonfarm uses range from moderate to severe. Most areas of these soils are used for crops. Some are in pasture and hay.

Representative profile of Hecla fine sandy loam in an area of Hecla-Hamar fine sandy loams in a cultivated field, 1,270 feet east and 150 feet south of the northwest corner of sec. 32, T. 129 N., R. 48 W.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—8 to 16 inches, very dark gray (10YR 3/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; very friable; neutral; clear, wavy boundary.

AC—16 to 22 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; dark grayish brown (10YR 4/2) when dry; weak, coarse, subangular blocky structure parting to weak, fine, granular; very friable; neutral; clear, wavy boundary.

C1—22 to 32 inches, dark grayish-brown (10YR 4/2) loamy fine sand; grayish brown (10YR 5/2) when dry; few, fine, faint, dark-brown (10YR 4/3) mottles; weak, coarse, subangular blocky structure parting to single grained; very friable; neutral; clear, wavy boundary.

C2—32 to 60 inches, light olive-brown (2.5Y 5/3) fine sand; light yellowish brown (2.5Y 6/3) when dry; few, fine, distinct, dark-brown (10YR 4/3) and common, medium, distinct, yellowish-brown (10YR 5/8) mottles; single grained; loose; neutral.

The A horizon is fine sandy loam, sandy loam, or loamy fine sand 14 to 30 inches thick. The AC horizon is very dark

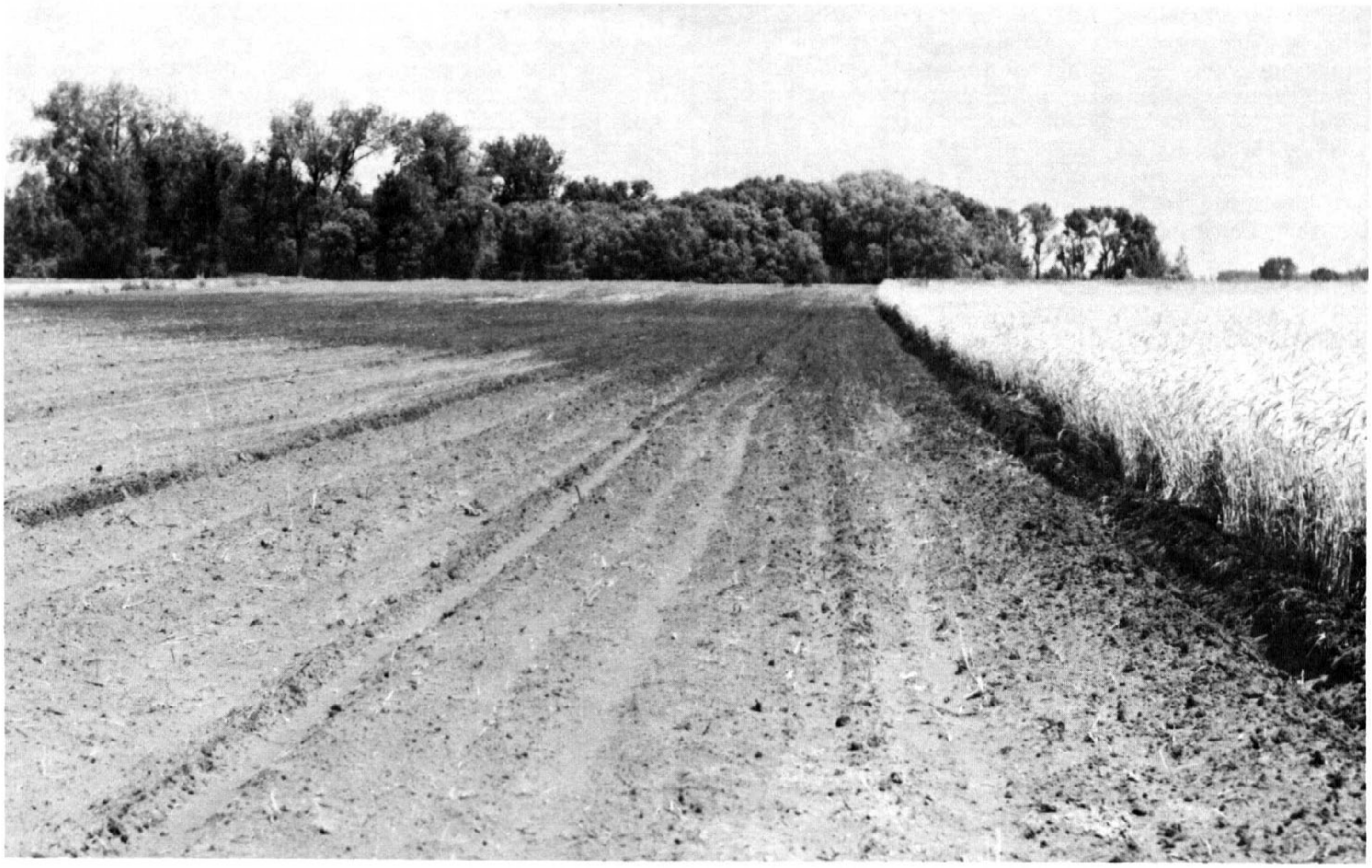

Figure 16.—Landscape on Hecla-Hamar loamy fine sands. The Hecla soil is in the light-colored area in the foreground, and the Hamar soil is in the dark-colored shallow depression.

brown or very dark grayish-brown loamy fine sand or fine sand. In some places, below a depth of 36 inches, there is a IIC horizon that ranges from silt loam to clay.

Hecla soils are associated with Arveson, Hamar, and Maddock soils. They are better drained than Arveson soils, and they do not have the zone of lime accumulation within 16 inches of the surface that is typical of those soils. They are better drained and have fewer mottles in the upper part of the profile than Hamar soils. They are more poorly drained and are dark colored to a greater depth than Maddock soils.

Hecla loamy fine sand, loamy substratum (0 to 3 percent slopes) (Hk).—This soil is on the Sheyenne Delta in areas that are small to medium in size and irregular in shape. This soil has a profile similar to that described as representative of the series, but the underlying material, below a depth of about 36 inches, is silt loam or silty clay loam. Included in mapping are small areas of Hamar soils.

This Hecla soil is moderately well drained. Runoff is slow. Permeability is rapid in the upper part of the profile and moderately slow in the substratum. The hazard of soil blowing is very severe.

This soil is suited to farming if soil blowing is controlled. Most areas are used for crops. The main concerns of management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IVe-2; Sands range site; windbreak suitability group 1.

Hecla-Hamar loamy fine sands (0 to 3 percent slopes) (Hm).—This mapping unit is on the Sheyenne Delta and the lake plain in broad areas that are small to large in size and irregular in shape. It is about 70 percent Hecla loamy fine sand, about 20 percent Hamar loamy fine sand, and about 10 percent Ulen and Arveson soils. The Hamar soil is in shallow depressions, and the Hecla soil is in slightly higher positions (fig. 16).

The Hecla soil has a profile similar to that described as representative of the series, but the surface layer is loamy fine sand.

The Hecla soil is moderately well drained and the Hamar soil is somewhat poorly drained or poorly drained. The water table in the Hamar soil is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall, but it seldom interferes with tillage. Runoff is slow. Permeability is rapid. The hazard of soil blowing is very severe.

This soil complex is suited to farming if soil blowing is controlled. Most areas are used for crops, but some areas are in native hay and pasture. The main concerns in management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IVe-2. Hecla soil in Sands range site and windbreak suitability group 1, Hamar soil in Subirrigated range site and windbreak suitability group 2.

Hecla-Hamar loamy fine sands, severely eroded (0 to 3 percent slopes) (Hm3).—This mapping unit is on the Sheyenne Delta in slightly hummocky areas that are small to medium in size and irregular in shape. It is about 80 percent Hecla loamy fine sand and about 20 percent Hamar loamy fine sand.

These soils have profiles similar to those described as representative of their respective series, but they are severely eroded. Nearly all of the original dark-colored surface layer has been blown away. The remaining surface layer has a low content of organic matter and is highly susceptible to further soil blowing.

Nearly all areas have been cultivated, but the soils are poorly suited to crops. Because the soils are so highly susceptible to soil blowing, they are better suited to hay and pasture grasses than to most other uses. The main concerns of management are reestablishing permanent plant cover to prevent further soil blowing, building up the organic-matter content and fertility, and providing forage for livestock. Capability unit VIe-Sa. Hecla soil in Sands range site and windbreak suitability group 1, Hamar soil in Subirrigated range site and windbreak suitability group 2.

Hecla-Hamar fine sandy loams (0 to 3 percent slopes) (Hn).—This mapping unit is on the Sheyenne Delta and the lake plain in broad areas that are small to large in size and irregular in shape. It is about 70 percent Hecla fine sandy loam, about 20 percent Hamar fine sandy loam, and about 10 percent Arveson and Ulen soils. The Hamar soil is in shallow depressions, and the Hecla soil is in slightly higher positions.

The Hecla soil has the profile described as representative of the series. The Hamar soil has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam.

The Hecla soil is moderately well drained, and the Hamar soil is somewhat poorly drained or poorly drained. The Hamar soil has a water table within 1 to 3 feet of the surface in spring and in periods of heavy rainfall, but it seldom interferes with tillage. Runoff is slow. Permeability is rapid. The hazard of soil blowing is severe.

These soils are suited to farming, and most areas are used for crops. The main concerns of management are preventing soil blowing, conserving moisture, and maintaining fertility. Capability unit IIIe-3. Hecla soil in Sandy range site and windbreak suitability group 1, Hamar soil in Subirrigated range site and windbreak suitability group 2.

Hecla-Hamar-Arveson complex (0 to 3 percent slopes) (Ho).—This mapping unit is on the Sheyenne Delta in broad, slightly hummocky areas that are medium to large in size and irregular in shape. It is about 60 percent Hecla loamy fine sand, about 15 percent Hamar loamy fine sand, about 15 percent Arveson loam, and 10 percent Maddock and Ulen soils. The Hecla soil is on low hummocks, and the Hamar and Arveson soils are in shallow depressions and swales and on broad flats.

The Hecla soil has a profile similar to that described as representative of the series, but the surface layer is loamy fine sand. The Arveson soil has a profile similar to that described as representative of the series, but the surface layer is loam.

The Hecla soil is moderately well drained, and the Hamar and Arveson soils are poorly drained. The water table in the Hecla and Arveson soils is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Runoff is slow. Permeability is rapid. The hazard of soil blowing is very severe on the Hecla and Hamar soils.

These soils are suited to farming if soil blowing is controlled. The main concerns of management are preventing soil blowing, removing excess water from Hamar and Arveson soils, conserving water on the Hecla soil, and maintaining fertility. Capability unit IVe-2. Hecla soil in Sands range site and windbreak suitability group 1, Hamar soil in Subirrigated range site and windbreak suitability group 2, Arveson soil in Wet Meadow range site and windbreak suitability group 2.

Hecla-Maddock loamy sands (0 to 3 percent slopes) (Hr).—This mapping unit is on the Sheyenne Delta in broad nearly level areas that are small to large in size and irregular in shape. It is about 65 percent Hecla loamy sand, about 25 percent Maddock loamy sand, and 10 percent Hamar soils. Included in mapping are small areas of Hecla fine sand.

These soils have profiles similar to those described as representative of their respective series, but the surface layer and underlying material are loamy sand.

Runoff is slow. Permeability is rapid, and the available water capacity is low. The hazard of soil blowing is very severe.

These soils are suited to farming if soil blowing is controlled. The main concerns of management are preventing soil blowing, conserving moisture, and maintaining fertility. Capability unit IVe-2; Sands range site; Hecla soil in windbreak suitability group 1, Maddock soil in windbreak suitability group 5.

Hecla-Maddock sandy loams (0 to 3 percent slopes) (Hs).—This mapping unit is on the Sheyenne Delta in broad areas that are small to large in size and irregular in shape. It is about 60 percent Hecla sandy loam, about 30 percent Maddock sandy loam, and about 10 percent Arveson and Hamar soils.

The Hecla and Maddock soils have profiles similar to those described as representative of their respective series, but the surface layer is sandy loam and the underlying material is loamy sand or sand.

Runoff is slow. Permeability is rapid, and the available water capacity is low. The hazard of soil blowing is severe.

These soils are suited to farming. The main concerns of management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIIe-3; Sandy range site; Hecla soil in windbreak suitability group 1, Maddock soil in windbreak suitability group 5.

Hegne Series

The Hegne series consists of deep, poorly drained, nearly level soils on the lake plain. These soils are plane and slightly convex and have a zone of lime accumula-

tion within 16 inches of the surface. They formed in fine-textured lacustrine sediments.

In a representative profile the surface layer is black silty clay about 8 inches thick. The underlying material, to a depth of 22 inches, is dark-gray silty clay that contains a large amount of lime. Below this is olive-gray silty clay mottled with light olive brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow.

Hegne soils are well suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of Hegne soils are used for crops.

The Hegne soils in this survey area are mapped only with Fargo soils.

Representative profile of Hegne silty clay in an area of Fargo-Hegne silty clays, in a cultivated field, 2,380 feet south and 75 feet east of the northwest corner of sec. 1, T. 136 N., R. 49 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay; dark gray (10YR 4/1) when dry; strong, fine, granular structure; friable, sticky and plastic; neutral; slight effervescence; abrupt, smooth, boundary.

C1gca—8 to 22 inches, dark-gray (5Y 4/1) silty clay; gray (5Y 6/1) when dry; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; moderate, fine, subangular blocky structure; firm, sticky and plastic; mildly alkaline; violent effervescence; clear, wavy boundary.

C2g—22 to 36 inches, olive-gray (5Y 5/2) silty clay; light olive gray (5Y 6/2) when dry; few, medium, distinct, light olive-brown (2.5Y 5/6) mottles; weak, medium, subangular blocky structure; firm, sticky and plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

C3g—36 to 60 inches, olive-gray (5Y 5/2) silty clay; light olive gray (5Y 6/2) when dry; common, coarse, distinct, light olive-brown (2.5Y 5/6) mottles; massive; firm, sticky and plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray silty clay or clay 7 to 15 inches thick. The upper boundary of the Cca horizon is within 16 inches of the surface. The C horizon is commonly clay or silty clay lacustrine deposits. In some places below a depth of 30 inches it is glacial till of clay loam or clay texture.

Hegne soils are associated with Fargo soils, and they formed in the same kind of material as Grano soils. They have a zone of lime accumulation at a lesser depth than Fargo soils. They contain more lime in the upper part of the profile than Grano soils.

Kratka Series

The Kratka series consists of deep, poorly drained, nearly level soils on flats and in shallow depressions on the Sheyenne Delta. These soils formed in coarse and medium-textured lacustrine sediments.

In a representative profile the surface layer is black fine sandy loam about 10 inches thick. The subsoil, about 16 inches thick, is dark grayish-brown very friable loamy fine sand mottled with dark yellowish brown. The underlying material, to a depth of about 35 inches, is olive-gray loam mottled with yellowish brown. Below this is olive-gray silt loam mottled with yellowish brown.

Permeability is rapid in the upper part of the profile and moderately slow in the underlying material. The available water capacity is moderate. The organic-matter content is high, and fertility is medium. Runoff is slow.

Kratka soils are suited to farming. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some are used for hay and pasture.

Representative profile of Kratka fine sandy loam in a cultivated field, 1,050 feet west and 195 feet south of the northeast corner of sec. 32, T. 133 N., R. 51 W.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, fine, granular structure; very friable; neutral; abrupt, smooth boundary.

B2g—10 to 26 inches, dark grayish-brown (2.5Y 4/2) loamy fine sand; grayish brown (2.5Y 5/2) when dry; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, subangular blocky structure parting to weak, fine, granular; very friable; mildly alkaline; clear, wavy boundary.

IIC1gca—26 to 35 inches, olive-gray (5Y 5/2) loam; light olive gray (5Y 6/2) when dry; common, medium, prominent, yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

IIC2g—35 to 60 inches, olive-gray (5Y 5/2) silt loam; light olive gray (5Y 6/2) when dry; many, large, prominent, yellowish-brown (10YR 5/8) mottles; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; slight effervescence.

The A horizon is black or very dark gray and is 8 to 16 inches thick. The B horizon is dark-gray or dark grayish-brown loamy fine sand or fine sand. Distinct or prominent mottles are in this horizon. Depth to the IIC horizon ranges from 20 to 36 inches.

Kratka soils formed in the same kind of material as Towner soils. They are more poorly drained than Towner soils and have mottles at a lesser depth.

Kratka fine sandy loam (0 to 1 percent slopes) (Kr).—This soil is in shallow depressions and on broad flats on the Sheyenne Delta. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Towner soils.

This Kratka soil is poorly drained. Runoff is slow. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Permeability is rapid in the upper part of the profile and moderately slow in the substratum. If the surface layer is left bare and dry, the hazard of soil blowing is severe.

This soil is well suited to farming if excess water is removed. Most areas are used for crops, but some are used for hay and pasture. The main concerns of management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIIwe-3; Subirrigated range site; windbreak suitability group 2.

LaDelle Series

The LaDelle series consists of deep, moderately well drained, nearly level soils on stream terraces and bottom lands. These soils formed in medium-textured and moderately fine textured alluvial sediments.

In a representative profile the surface layer is black silty clay loam 24 inches thick. The subsoil is very dark brown, friable silty clay loam about 10 inches thick.

The underlying material, to a depth of 60 inches, is very dark grayish-brown silty clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow.

LaDelle soils are well suited to farming. Limitations for many nonfarm uses are moderate to severe. Most areas of these soils are used for crops. Some severely channeled areas are in pasture or woodland.

Representative profile of LaDelle silty clay loam in a cultivated field, 1,320 feet west and 2,080 feet north of the southeast corner of sec. 9, T. 135 N., R. 53 W. (1,320 feet west and 155 feet north of southeast corner of churchyard.)

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to weak, medium, crumb; friable, slightly sticky and plastic; neutral; abrupt, smooth boundary.

A12—7 to 22 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; medium, subangular blocky structure; friable, slightly sticky and plastic; neutral; clear, wavy boundary.

B2—22 to 34 inches, very dark brown (10YR 2/2) silty clay loam; dark grayish brown (10YR 4/2) when dry; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; friable, slightly sticky and plastic; mildly alkaline; strong effervescence; common threads and masses of soft lime; gradual, wavy boundary.

C—34 to 60 inches, very dark grayish-brown (10YR 3/2) silty clay loam; grayish brown (10YR 5/2) when dry; massive; slightly sticky and plastic; mildly alkaline; strong effervescence; common threads and masses of soft lime.

The A horizon is black or very dark gray and is 14 to 22 inches thick. In many places the A horizon of a buried soil is above a depth of 5 feet. The B horizon is very dark brown, dark brown, or very dark grayish brown. The C horizon is silt loam or silty clay loam. In some places strata of sand, silt, or clay are in the C horizon below a depth of 40 inches.

LaDelle soils formed in the same kind of material as Fairdale, LaPrairie, and Lamoure soils, and they are associated with Wahpeton soils. They are darker colored than Fairdale soils. They contain less sand than LaPrairie soils. They are better drained than Lamoure soils. They contain less clay than Wahpeton soils.

LaDelle silty clay loam (0 to 3 percent slopes) (La).—This soil is on stream terraces and bottom lands. Areas are medium in size and irregular in shape. This soil has the profile described as representative of the series. Included in mapping are small areas of Fairdale soils.

This LaDelle soil is moderately well drained. Runoff is slow. Permeability is moderate, and the available water capacity is high. The hazard of erosion is slight. This soil is occasionally flooded for short periods when streams overflow.

This soil is well suited to farming. Most areas are used for crops, but some small areas are in native woods. The main concerns of management are maintaining fertility and tilth and conserving moisture. Capability unit IIc-6; Overflow range site; windbreak suitability group 1.

LaDelle and Wahpeton soils, channeled (0 to 4 percent slopes) (Lb).—This mapping unit is on stream terraces and bottom lands that are highly dissected by abandoned channels and oxbows. Areas are small to medium in size. Some areas are LaDelle silty clay loam, some are Wahpeton silty clay, and some areas contain both soils. Included in mapping are small areas of Fairdale, Cashel, and Lamoure soils.

Both LaDelle and Wahpeton soils are moderately well drained. They are occasionally flooded for short periods when streams overflow after rapid snowmelt or heavy rains. Runoff is slow. Permeability is moderately slow in the Wahpeton soil and moderate in the LaDelle soil.

These soils are suited to woodland or grazing. They are too highly dissected and too irregular in slope for cultivation. The main concern of management is maintaining a permanent plant cover to help prevent erosion and to provide high-quality forage for livestock. Capability unit VIe-Ov. LaDelle soil in Overflow range site, Wahpeton soil in Clayey range site; windbreak suitability group 1.

Lamoure Series

The Lamoure series consists of deep, poorly drained, nearly level soils on stream bottom land. These soils formed in moderately fine textured and medium-textured alluvial sediments.

In a representative profile the surface layer is black silty clay loam about 16 inches thick. The subsoil is very dark gray friable silty clay loam about 14 inches thick. The underlying material, to a depth of 40 inches, is dark-gray silty clay loam. Below this is dark grayish-brown silty clay loam mottled with yellowish brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. Runoff is slow. These soils are frequently flooded, and the water table is within 2 to 5 feet of the surface.

Lamoure soils are well suited to hay and pasture. The better drained areas are suited to cultivated crops. Limitations for many nonfarm uses are severe. Most areas are used for hay and pasture. Some of the better drained areas are used for crops.

Representative profile of Lamoure silty clay loam in a hay meadow, 1,750 feet north and 200 feet east of the southwest corner of sec. 30, T. 132 N., R. 51 W.

A1—0 to 16 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; weak, medium, crumb structure; friable, slightly sticky and slightly plastic; mildly alkaline; slight effervescence; clear, wavy boundary.

B2—16 to 30 inches, very dark gray (10YR 3/1) silty clay loam; gray (10YR 5/1) when dry; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; friable, slightly sticky and plastic; mildly alkaline; slight effervescence; gradual, wavy boundary.

C1g—30 to 40 inches, dark-gray (2.5Y 4/1) silty clay loam; gray (2.5Y 6/1) when dry; few, fine, faint, light olive-brown (2.5Y 5/4) mottles; weak, fine, subangular blocky structure; friable, sticky and plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C2g—40 to 60 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; light brownish gray (2.5Y 6/2) when dry; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; massive; friable, sticky and plastic; mildly alkaline; slight effervescence.

The A horizon is silt loam or silty clay loam and is 12 to 20 inches thick. In many places the A horizons of buried soils are below a depth of 36 inches. The B horizon is black or

very dark gray silt loam or silty clay loam 12 to 16 inches thick. The C horizon is silt loam or silty clay loam. In some places strata of sand or clay are in the C horizon below a depth of 40 inches.

Lamoure soils formed in the same kind of material as LaDelle and LaPrairie soils. They are more poorly drained than those soils.

Lamoure silty clay loam (0 to 1 percent slopes) (Lm).—This soil is on stream bottom land in areas that are medium to large in size and irregular in shape. Included in mapping are some areas that are moderately saline.

This soil is poorly drained. The water table is within 2 feet of the surface in spring and in periods of heavy rainfall. Permeability is moderate. Runoff is slow. This soil is frequently flooded when streams, overflow. The hazard of erosion is slight.

Some of the better drained areas of this soil are used for crops, but many areas are used for hay and pasture. This soil is suited to farming, but excess water is a problem. The main concerns of management are removing excess water and maintaining fertility. Capability unit IIw-4L; Subirrigated range site; windbreak suitability group 2.

Langhei Series

The Langhei series consists of deep, somewhat excessively drained, hilly soils on convex surfaces on the glacial till plain. These soils formed in calcareous, medium-textured and moderately fine textured glacial till.

In a representative profile the surface layer is dark grayish-brown loam about 7 inches thick. The underlying material is light olive-brown clay loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is low, and fertility is low. Runoff is very rapid.

Langhei soils are well suited to pasture. They are steep and are poorly suited to crops. Limitations for many nonfarm uses are moderate to severe. Most areas of these soils are used for pasture. Some areas are used for crops.

The Langhei soils in this survey area are mapped only with Barnes and Buse soils.

Representative profile of Langhei loam in an area of Barnes-Buse-Langhei loams, hilly, in a cultivated field, 1,585 feet north and 265 feet east of the southwest corner of sec. 28, T. 130 N., R. 51 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loam; light brownish gray (10YR 6/2) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence; abrupt, smooth boundary.

C1ca—7 to 25 inches, light olive-brown (2.5Y 5/3) clay loam; light yellowish brown (2.5Y 6/3) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; common soft lime segregations; gradual, wavy boundary.

C2—25 to 60 inches, light olive-brown (2.5Y 5/3) clay loam; light yellowish brown (2.5Y 6/3) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon in noncultivated areas is black or very dark gray and is 2 to 4 inches thick. After the A horizon has been mixed with the upper part of the C horizon the Ap horizon is dark gray, gray, dark grayish brown, or grayish brown. The C horizon is loam or clay loam.

Langhei soils are associated with Barnes and Buse soils. They have a thinner A horizon than Barnes soils, and they do not have the B horizon that is typical of those soils. They have a thinner A horizon in noncultivated areas than Buse soils and a lighter colored Ap horizon in cultivated areas than those soils.

LaPrairie Series

The LaPrairie series consists of deep, moderately well drained, nearly level soils on stream terraces and bottom lands. These soils formed in medium-textured and moderately fine textured alluvial sediments.

In a representative profile the surface layer is black silt loam about 15 inches thick. The subsoil is very dark gray, very friable loam about 20 inches thick. The underlying material is very dark grayish-brown clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow.

LaPrairie soils are well suited to farming. Limitations for many nonfarm uses are moderate to severe. Most areas of these soils are used for crops. Some areas are in native woods.

Representative profile of LaPrairie silt loam in a cultivated field, 120 feet east and 2,240 feet south of the northwest corner of sec. 30, T. 131 N., R. 49 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to moderate, fine, granular; very friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) silt loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure; very friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

B2—15 to 35 inches, very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) when dry; weak, medium, prismatic structure parting to weak, medium, subangular blocky; very friable, slightly sticky and slightly plastic; neutral; gradual, wavy boundary.

C—35 to 60 inches, very dark grayish-brown (10YR 3/2) clay loam; grayish brown (10YR 5/2) when dry; weak, coarse and medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray loam or silt loam 14 to 26 inches thick. In many places the A horizons of buried soils are below a depth of 40 inches. The B horizon is black, very dark gray, very dark brown, very dark grayish-brown, or dark-brown loam, silt loam, or light clay loam. In some places below a depth of 40 inches the C horizon contains strata of sand, silt, or clay.

LaPrairie soils formed in the same kind of material as Fairdale, LaDelle, and Lamoure soils. They are darker colored than Fairdale soils. They contain more sand than LaDelle soils. They are better drained than Lamoure soils.

LaPrairie silt loam (0 to 3 percent slopes) (Lp).—This soil is on stream terraces and bottom lands. Areas are small to large in size and irregular in shape. Included in mapping are small areas of Fairdale soils.

This LaPrairie soil is moderately well drained. Runoff is slow. Permeability is moderate. The hazard of erosion is slight. The soil is occasionally flooded for short periods in spring when streams overflow after rapid snowmelt or heavy rainfall.

This soil is well suited to farming. Most areas are used for crops. Some small areas are in native woods. The main concerns of management are maintaining fertility and conserving moisture. Capability unit IIc-6; Overflow range site; windbreak suitability group 1.

Maddock Series

The Maddock series consists of deep, well-drained, undulating to rolling soils on convex surfaces on the Sheyenne Delta. These soils formed in coarse-textured lacustrine and eolian deposits.

In a representative profile the surface layer is black loamy fine sand about 14 inches thick. The subsoil is dark-brown, loose fine sand about 16 inches thick. To a depth of 48 inches the underlying material is grayish-brown fine sand. Below this is dark grayish-brown fine sand mottled with dark brown.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate, and fertility is low. Runoff is slow.

Maddock soils are suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for pasture and hay. Some areas are used for crops.

Representative profile of Maddock loamy fine sand in an area of Maddock-Hecla-Hamar loamy fine sands, undulating, in a native grass pasture, 0.3 mile north and 240 feet east of the southwest corner of sec. 1, T. 134 N., R. 54 W.

A1—0 to 14 inches, black (10YR 2/1) loamy fine sand; dark gray (10YR 4/1) when dry; weak, fine, crumb structure parting to single grained; loose; neutral; gradual, wavy boundary.

B2—14 to 30 inches, dark-brown (10YR 3/3) fine sand; brown (10YR 5/3) when dry; single grained; loose; neutral; gradual, wavy boundary.

C1—30 to 48 inches, grayish-brown (10YR 5/2) fine sand; light brownish gray (10YR 6/2) when dry; single grained; loose; mildly alkaline; gradual, wavy boundary.

C2—48 to 60 inches, dark grayish-brown (10YR 4/2) fine sand; light brownish gray (10YR 6/2) when dry; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is black or very dark gray loamy fine sand, loamy sand, fine sandy loam, or sandy loam 8 to 16 inches thick. The B horizon is very dark brown, very dark grayish-brown, or dark-brown fine sand or loamy fine sand. The C horizon is fine sand or loamy fine sand. Below a depth of 40 inches in some places there is a IIC horizon of silt loam to silty clay.

Maddock soils are associated with Hecla, Hamar, and Egeland soils and they formed in the same kind of material as Serden soils. They are better drained than Hecla and Hamar soils. They are sandier than Egeland soils. They have a thicker A horizon than Serden soils.

Maddock loamy fine sand, rolling (6 to 9 percent slopes) (MdC).—This soil is on low hills and slopes along streams in the Sheyenne Delta. Areas are small to medium in size and irregular in shape.

Included with this soil in mapping are small areas of Hecla and Serden soils. Also included are small areas where the surface layer is fine sandy loam and other small areas where slopes range from 9 to 12 percent.

Runoff is slow. Permeability is rapid, and the available water capacity is low. The hazard of soil blowing is very severe.

Most areas of this soil are used for grazing, but some areas are used for crops. The soil, however, is not suited to farming. The main concern of management is maintaining a permanent plant cover to help prevent soil blowing and to provide forage for livestock. Capability unit VIe-Sa; Sands range site; windbreak suitability group 5.

Maddock-Hecla loamy fine sands, undulating (3 to 6 percent slopes) (MhB).—This mapping unit is on low hills and ridges on the Sheyenne Delta. It is about 65 percent Maddock loamy fine sand and about 35 percent Hecla loamy fine sand. Areas are small to large in size and irregular in shape.

Included with this soil in mapping are small areas of Hamar soils. Also included are small areas of Maddock and Hecla soils where the slope is less than 3 percent.

The Hecla soil has a profile similar to that described as representative of the series, but the surface layer is loamy fine sand.

Runoff is slow. Permeability is rapid, and the available water capacity is low. The hazard of soil blowing is very severe.

These soils are suited to farming if soil blowing is controlled. Some areas are used for crops and some are used for grazing. The main concerns of management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IVe-2; Sands range site. Maddock soil in windbreak suitability group 5, Hecla soil in windbreak suitability group 1.

Maddock-Hecla-Hamar loamy fine sands, undulating (3 to 6 percent slopes) (MIB).—This mapping unit is in hummocky areas on the Sheyenne Delta. It is about 50 percent Maddock loamy fine sand, about 25 percent Hecla loamy fine sand, about 15 percent Hamar loamy fine sand, and 10 percent poorly drained Arveson soil and very poorly drained Venlo soil. The soils are on low dunes and intervening flats and in shallow depressions and swales. Areas are medium to large in size and irregular in shape.

The Maddock soil is on the crests and upper parts of low dunes. The Hecla soil is on lower parts. The Hamar soil is on flats and in shallow depressions and swales. The Hecla soil has a profile similar to that described as representative of the series, but the surface layer is loamy fine sand.

The Maddock soil is well drained, the Hecla soil is moderately well drained, and the Hamar soil is somewhat poorly drained and poorly drained. Runoff is slow. Permeability is rapid, and the available water capacity is low. The hazard of soil blowing is very severe.

These soils are suited to farming if soil blowing is controlled. Some areas are used for crops, but many areas are used for grazing and hay. The main concerns of management are preventing soil blowing, maintaining fertility, and conserving water. Capability unit IVe-2. Maddock soil in Sands range site and windbreak suitability group 5, Hecla soil in Sands range site and windbreak suitability group 1, Hamar soil in Subirrigated range site and windbreak suitability group 2.

Marsh

Marsh (Mr) consists of shallow lakes, depressions, and lowlands that are wet throughout most of the year. The vegetation is mainly bulrushes, cattails, reeds, and other aquatic plants that have little or no value as livestock feed. Areas of Marsh are valuable as habitat for wildlife. Capability unit VIIIw-1.

Nutley Series

The Nutley series consists of deep, well-drained, rolling soils along streams. These fine-textured soils are on the lake plain. They formed in lacustrine sediments.

In a representative profile the surface layer is black silty clay about 5 inches thick. The subsoil is firm clay about 18 inches thick. The upper part is very dark grayish brown, and the lower part is dark grayish brown. The underlying material, to a depth of 33 inches, is mixed dark grayish-brown and olive-brown clay. Below this is 10 inches of olive-brown clay and 17 inches of mixed olive and olive-gray clay.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is rapid.

Nutley soils are suited to farming. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some areas are in pasture.

Representative profile of Nutley silty clay, rolling, in a pasture, 315 feet west and 2,225 feet south of the northeast corner of sec. 13, T. 136 N., R. 49 W.

A1—0 to 5 inches, black (10YR 2/1) silty clay; very dark gray (10YR 3/1) when dry; moderate, fine, subangular blocky structure parting to strong, fine, granular; firm, sticky and very plastic; slightly acid; clear, irregular boundary.

B21—5 to 15 inches, very dark grayish-brown (2.5Y 3/2) clay; grayish brown (2.5Y 5/2) when dry; moderate, medium, prismatic structure parting to strong, fine, angular blocky; firm, sticky and very plastic; moderately alkaline; slight effervescence; gradual, irregular boundary.

B22ca—15 to 23 inches, dark grayish-brown (2.5Y 4/2) clay; light brownish gray (2.5Y 6/2) when dry; moderate, medium, prismatic structure parting to strong, fine, angular blocky; firm, sticky and very plastic; mildly alkaline; violent effervescence; common soft lime segregations; gradual, wavy boundary.

C1—23 to 33 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/3) clay; light brownish gray (2.5Y 6/2) and light yellowish brown (2.5Y 6/3) when dry; strong, fine, angular blocky structure; firm, sticky and very plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C2—33 to 43 inches, olive-brown (2.5Y 4/3) clay; light yellowish brown (2.5Y 6/3) when dry; few, fine, prominent, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, prismatic structure parting to strong, fine, angular blocky; firm, sticky and very plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C3—43 to 60 inches, olive (5Y 5/3) and olive-gray (5Y 5/2) clay; pale yellow (5Y 7/3) and light gray (5Y 7/2) when dry; moderate, thick, platy structure; firm, sticky and very plastic; mildly alkaline; strong effervescence.

The solum ranges from 12 to 24 inches in thickness. The A horizon is black or very dark gray clay or silty clay 4 to 8 inches thick. In many places tongues of the A horizon extend downward through the B horizon. The B horizon is very dark grayish-brown, dark grayish-brown, grayish-brown, dark-gray, or gray silty clay or clay. The C horizon is silty clay or clay.

Nutley soils formed in the same kind of material as Wahpeton soils. They are dark colored to a lesser depth and are better drained than Wahpeton soils.

Nutley silty clay, rolling (6 to 9 percent slopes) (NuC). —This soil is along the Red River and other streams in the lake plain. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Fargo soils.

This Nutley soil is well drained. Permeability is slow. Runoff is rapid, and the hazard of erosion is severe. This soil is difficult to work and to keep in good tilth.

This soil is suited to farming, and most areas are used for crops. The main concerns of management are preventing erosion, maintaining tilth and fertility, and conserving water. Capability unit IIIe-4; Clayey range site; windbreak suitability group 4.

Overly Series

The Overly series consists of deep, moderately well drained, nearly level and undulating soils on the lake plain. These soils are plane and slightly convex. They formed in medium-textured and moderately fine textured lacustrine sediments.

In a representative profile (fig. 17) the surface layer is black silty clay loam about 9 inches thick. The subsoil is very dark gray, friable silty clay loam about 15 inches thick. The underlying material is light olive-brown silty clay loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow to medium.

Overly soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Overly silty clay loam in a cultivated field, 70 feet south and 300 feet west of the northeast corner of sec. 20, T. 132 N., R. 52 W.

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; moderate, fine, granular structure; friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

B2—9 to 24 inches, very dark gray (10YR 3/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, coarse and medium, prismatic structure parting to moderate, medium, angular blocky; friable, slightly sticky and plastic; neutral; clear, irregular boundary.

C1ca—24 to 36 inches, light olive-brown (2.5Y 5/4) silty clay loam; light yellowish brown (2.5Y 6/3) when dry; moderate, coarse and medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; clear, wavy boundary.

C2—36 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam; light yellowish brown (2.5Y 6/3) when dry; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; massive; friable, sticky and plastic; mildly alkaline; strong effervescence; few soft lime segregations.

The solum ranges from 16 to 30 inches in thickness. The A horizon is very dark gray or black silt loam or silty clay loam 8 to 14 inches thick. The B horizon is very dark gray, very dark brown, very dark grayish-brown, or dark grayish-brown silt loam or silty clay loam. The C horizon is silt loam or silty clay loam. In some places below a depth of 30 inches there is a IIC horizon of clay or silty clay.

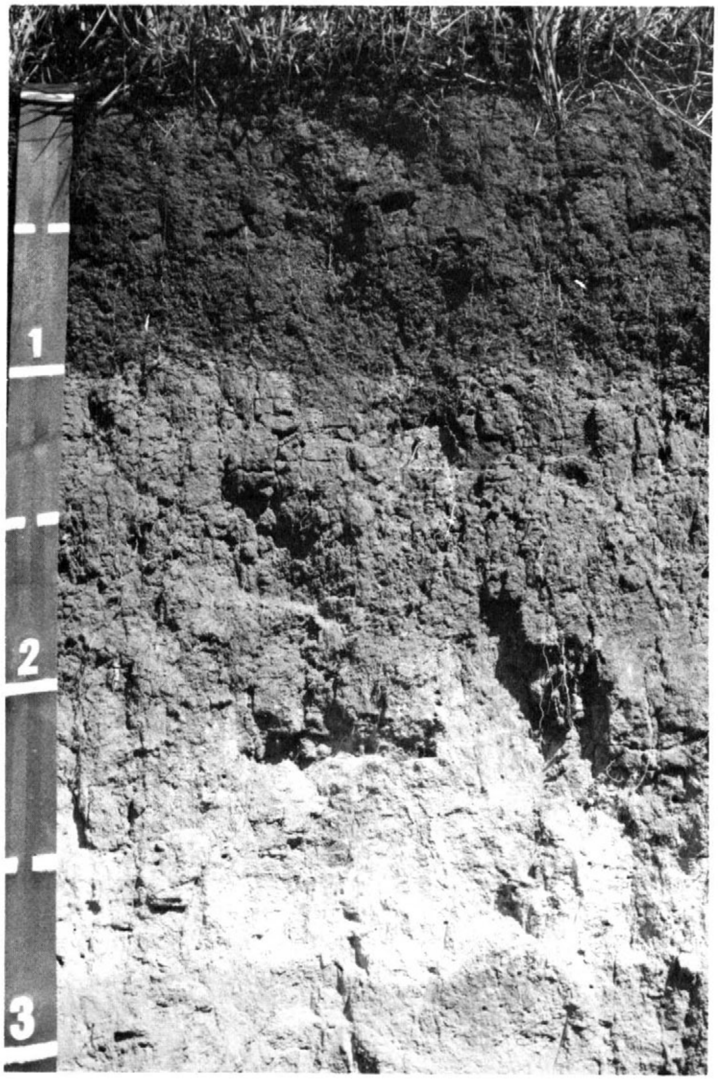

Figure 17.—Profile of Overly silty clay loam showing thick, dark-colored surface layer.

Overly soils are associated with Bearden, Beotia, and Galchutt soils. They are better drained and are deeper over lime than Bearden soils. They are not so well drained as Beotia soils. They are better drained than Galchutt soils and do not have the A2 horizon and clay IIB horizon that is typical of those soils.

Overly silty clay loam (0 to 3 percent slopes) (Oc).—This soil is on the lake plain in broad flats that are medium to large in size and irregular in shape. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Bearden and Perella soils. Also included are some areas of soils that have a silty clay or clay substratum below a depth of 30 to 40 inches.

This soil is moderately well drained. Permeability is moderately slow. Runoff is slow, and the hazard of erosion is slight.

This soil is well suited to farming, and most areas are used for crops. The main concerns of management are maintaining fertility and conserving water. Capability unit IIc-6; Silty range site; windbreak suitability group 1.

Overly-Bearden silt loams, moderately saline (0 to 3 percent slopes) (Od).—This mapping unit is on the lake plain in broad flats that are small to medium in size and irregular in shape. It is about 55 percent Overly silt loam, about 35 percent Bearden silt loam, and 10 percent moderately saline Glyndon soils. Also included are small areas of nonsaline soils. The Overly and Bearden soils have profiles similar to those described as representative of their respective series, but the surface layer is silt loam and it contains a moderate amount of salts.

Runoff is slow. Permeability is moderately slow, and the hazard of erosion is slight. The level of salts in these soils is high enough to adversely affect crop growth and vigor.

These soils are suited to farming, and most areas are used for crops. Crops do not grow so well on these soils as they do on the nonsaline Overly and Bearden soils. The main concern of management is reducing the salinity level. Capability unit IIIs-4L. Overly soil in Silty range site and windbreak suitability group 10. Bearden soil in Subirrigated range site and windbreak suitability group 10.

Overly-Bearden silty clay loams, moderately saline (0 to 3 percent slopes) (Oe).—This mapping unit is on the lake plain in broad flats that are small to medium in size and irregular in shape. It is about 60 percent Overly silty clay loam and about 40 percent Bearden silty clay loam. Included in mapping are small areas of nonsaline soils. These soils have profiles similar to those described as representative of their respective series, but the surface layer contains a moderate amount of salts.

Permeability is moderately slow. Runoff is slow, and the hazard of erosion is slight. The level of salts in these soils is high enough to adversely affect crop growth and vigor.

These soils are suited to farming, and most areas are used for crops. Crops do not grow so well on these soils as they do on the nonsaline Overly and Bearden soils. The main concern of management is reducing the salinity level. Capability unit IIIs-4L. Overly soil in Silty range site and windbreak suitability group 10, Bearden soil in Subirrigated range site and windbreak suitability group 10.

Overly-Beotia silty clay loams, undulating (3 to 6 percent slopes) (OlB).—This mapping unit is on low hills and slopes along streams on the lake plain. It is about 55 percent Overly silty clay loam and about 45 percent Beotia silty clay loam. Areas are small to medium in size and irregular in shape. The Beotia soil has the profile described as representative of the series.

Included with these soils in mapping are small areas where the slopes range from 6 to 9 percent. Also included are small areas where the surface layer is silt loam.

The Overly soil is moderately well drained, and the Beotia soil is well drained. Permeability is moderately slow in the Overly soil and moderate in the Beotia soil. Runoff is medium, and the hazard of erosion is moderate.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are preventing erosion, conserving moisture, and maintaining fertility. Capability unit IIe-6; Silty range site; Overly soil in windbreak suitability group 1; Beotia soil in windbreak suitability group 3.

Parnell Series

The Parnell series consists of deep, very poorly drained, nearly level soils in depressions in the glacial till plain. These soils formed in medium textured and moderately fine textured alluvium and the underlying loamy glacial till.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil is firm silty clay loam about 21 inches thick. The upper part is black, and the lower part is very dark gray. The underlying material is olive-gray clay loam mottled with olive brown, dark brown, yellowish brown, and dark yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow, and these soils are frequently ponded.

Parnell soils are suited to farming if they are drained. They are suited to hay and pasture. Limitations for many nonfarm uses are severe. Most areas of these soils are used for hay and pasture. Some drained areas are used for crops.

Representative profile of Parnell silty clay loam in a pasture, 1,980 feet north and 330 feet west of the southeast corner of sec. 34, T. 130 N., R. 52 W.

A1—0 to 13 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; moderate, fine, granular structure; friable, slightly sticky and slightly plastic; slightly acid; gradual, wavy boundary.

B21tg—13 to 25 inches, black (N 2/0) silty clay loam; dark gray (N 4/0) when dry; weak, coarse, prismatic structure parting to strong, fine, angular blocky; firm, very sticky and very plastic; slightly acid; gradual, wavy boundary.

B22tg—25 to 34 inches, very dark gray (5Y 3/1) silty clay loam; gray (5Y 5/1) when dry; few, fine, distinct, very dark grayish-brown (2.5Y 3/2) mottles; weak, coarse, prismatic structure parting to strong, fine, angular blocky; firm, very sticky and very plastic; neutral; clear, wavy boundary.

C1g—34 to 40 inches, olive-gray (5Y 5/2) clay loam; light olive gray (5Y 6/2) when dry; common, medium, prominent, olive-brown (2.5Y 4/4) and yellowish-brown (10YR 5/4) mottles; massive; firm, sticky and plastic; mildly alkaline; strong effervescence; common large soft masses of lime; gradual, wavy boundary.

C2g—40 to 60 inches, olive-gray (5Y 5/2) clay loam; light olive gray (5Y 6/2) when moist; many, large, prominent, dark-brown (7.5YR 4/4), dark yellowish-brown (10YR 4/4), and yellowish-brown (10YR 5/8) mottles; massive; firm, sticky and plastic; mildly alkaline; strong effervescence.

The A horizon is 10 to 18 inches thick. The B2 horizon is black, very dark gray, or very dark grayish-brown silty clay loam, clay loam, silty clay, or clay. The C horizon is loam, silt loam, clay loam, or silty clay loam.

Parnell soils are associated with Tonka soils. They do not have the A2 horizon that is typical of Tonka soils.

Parnell silty clay loam (0 to 1 percent slopes) (Pc).—This soil is on the glacial till plain in deep depressions that are small to medium in size and mostly round or oval in shape. It has the profile described as representative of the series. Included in mapping are small areas of Vallers soils.

This Parnell soil is very poorly drained. It is frequently ponded in spring and in periods of heavy rainfall. Permeability is slow.

This soil is suited to farming if excess water is removed. If not drained, it is suited to hay and pasture. A few areas are used for crops, but most areas are used for grazing and hay. The main concern of management is removing excess water. Capability unit IIIw-6; Wetland range site; windbreak suitability group 2.

Parnell and Tonka silty clay loams (0 to 1 percent slopes) (Pd).—This mapping unit is on the glacial till plain in shallow depressions that are small to medium in size and are mostly round or oval in shape. Some areas are Parnell silty clay loam, some are Tonka silty clay loam, and some areas contain both soils. Included in mapping are small areas of Vallers soils.

The Tonka soil has a profile similar to that described as representative of the series, but the surface layer is silty clay loam.

The Parnell soil is very poorly drained, and the Tonka soil is poorly drained. These soils are frequently ponded in spring and in periods of heavy rainfall. Permeability is slow in both soils.

These soils are well suited to farming if excess water is removed. Undrained areas are better suited to hay and pasture than to most other uses. Some areas are used for crops, but most are used for grazing and hay. The main concern of management is removing excess water. Capability unit IIw-6. Parnell soil in Wetland range site and windbreak suitability group 2, Tonka soil in Wet Meadow range site and windbreak suitability group 2.

Peat

Peat (Pe) is on the Sheyenne Delta in deeply entrenched drainageways that empty into the Sheyenne River. Areas are small and mostly long and narrow.

Peat is an organic soil. The surface layer and underlying material to a depth of about 50 inches are black and very dark grayish-brown peat. Drainage is very poor, and the water table is at the surface most of the time. The vegetation is mainly coarse grasses, sedges, and birch trees.

Peat can be grazed during dry periods. It also provides wildlife habitat. Capability unit Vw-WL; Wetland range site; windbreak suitability group 10.

Peever Series

The Peever series consists of deep, well-drained, nearly level and undulating soils on the glacial till plain. These soils are plane and convex. They formed in moderately fine textured glacial till.

In a representative profile the surface layer is black clay loam about 7 inches thick. The subsoil is about 18 inches thick. The upper part is very dark brown, firm

silty clay; the middle part is very dark grayish-brown, firm silty clay; and the lower part is olive-brown, firm clay loam. The underlying material is light olive-brown clay loam.

Permeability is slow in the subsoil and moderately slow in the underlying material. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow to medium.

Peever soils are suited to farming. Limitations for many nonfarm uses are moderate to severe. Most areas of these soils are used for crops.

Representative profile of Peever clay loam in an area of Forman-Peever clay loams, undulating, in a cultivated field, 250 feet east and 2,140 feet south of the northwest corner of sec. 17, T. 129 N., R. 51 W., Lake Traverse Lands.

Ap—0 to 7 inches, black (10YR 2/1) clay loam; very dark gray (10YR 3/1) when dry; moderate, fine, granular structure; friable, slightly sticky and slightly plastic; slightly acid; abrupt, smooth boundary.

B21t—7 to 14 inches, very dark brown (10YR 2/2) silty clay; dark gray (10YR 4/1) when dry; moderate, medium, prismatic structure parting to strong, medium, angular blocky; firm, sticky and plastic; thin, continuous clay films on faces of peds; neutral; clear, wavy boundary.

B22t—14 to 19 inches, very dark grayish-brown (2.5Y 3/2) silty clay; dark grayish brown (2.5Y 4/2) when dry; moderate, medium, prismatic structure parting to strong, medium, angular blocky; firm, sticky and plastic; thin, continuous clay films on faces of peds; neutral; clear, wavy boundary.

B3ca—19 to 25 inches, olive-brown (2.5Y 4/3) clay loam; light yellowish brown (2.5Y 6/3) when dry; weak, medium, prismatic structure parting to moderate, medium, angular blocky; firm, sticky and plastic; mildly alkaline; strong effervescence; clear, wavy boundary.

C1ca—25 to 32 inches, light olive-brown (2.5Y 5/3) clay loam; pale yellow (2.5Y 7/3) when dry; weak, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2—32 to 60 inches, light olive-brown (2.5Y 5/3) clay loam; pale yellow (2.5Y 7/3) when dry; few, fine, prominent, reddish-brown (5YR 4/4) mottles; massive; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon is very dark gray or black and is 6 to 10 inches thick. The B2t horizon is black, very dark gray, very dark brown, very dark grayish-brown, or dark grayish-brown clay, silty clay, or heavy clay loam. It is 9 to 29 inches thick.

Peever soils are associated with Forman soils. They contain more clay in the B horizon than Forman soils.

Peever-Forman clay loams (0 to 3 percent slopes) (Pf).—This mapping unit is on the glacial till plain in nearly level areas that are small to medium in size and irregular in shape. It is about 60 percent Peever clay loam, about 30 percent Forman clay loam, and 10 percent Aastad and Tonka soils.

The Forman soil has a profile similar to that described as representative of the series, but the surface layer is clay loam.

These soils are well drained. Runoff is slow. Permeability in the Peever soil is slow in the subsoil and moderately slow in the underlying material. In the Forman soil it is moderate in the subsoil and moderately slow in the underlying material. The hazard of erosion is slight.

These soils are well suited to farming, and most areas are used for crops. The main concerns of management are conserving water and maintaining fertility. Capability unit IIc-6. Peever soil in Clayey range site and windbreak suitability group 4, Forman soil in Silty range site and windbreak suitability group 3.

Perella Series

The Perella series consists of deep, poorly drained, nearly level soils in swales, shallow depressions, and on flats on the lake plain. These soils formed in medium-textured and moderately fine textured lacustrine sediments.

In a representative profile the surface layer is black silty clay loam about 12 inches thick. The subsoil, about 10 inches thick, is friable very dark grayish-brown silty clay loam mottled with dark brown and yellowish brown. The underlying material, to a depth of about 32 inches, is olive silty clay loam mottled with dark yellowish brown. Below this is olive-gray silty clay mottled with yellowish brown and dark yellowish brown.

Permeability is moderately slow to a depth of 32 inches and slow below that depth. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow.

Perella soils are well suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops.

Representative profile of Perella silty clay loam, moderately deep over clay, in a cultivated field, 260 feet west and 60 feet south of the northeast corner of sec. 35, T. 133 N., R. 49 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; moderate, medium, subangular blocky structure parting to moderate, fine, crumb; friable, sticky and plastic; neutral; abrupt, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silty clay loam; very dark gray (10YR 3/1) when dry; moderate, fine, subangular blocky structure; friable, sticky and plastic; neutral; clear, wavy boundary.

B2g—12 to 22 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam; grayish brown (2.5Y 5/2) when dry; common, fine, distinct, yellowish-brown (10YR 5/8) and dark-brown (10YR 4/3) mottles; weak, coarse, prismatic structure parting to moderate, medium, angular blocky; friable, sticky and plastic; neutral; clear, wavy boundary.

C1g—22 to 32 inches, olive (5Y 5/3) silty clay loam; pale olive (5Y 6/3) when dry; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable, sticky and plastic; neutral; clear, wavy boundary.

IIC2g—32 to 60 inches, olive-gray (5Y 5/2) silty clay; light olive gray (5Y 6/2) when dry; many, medium, prominent, yellowish-brown (10YR 5/8) and dark yellowish-brown (10YR 4/4) mottles; firm, very sticky and very plastic; mildly alkaline; strong effervescence; common, large, soft lime masses.

The A horizon is loam, silt loam, clay loam, or silty clay loam and is 8 to 18 inches thick. The B horizon is very dark gray, very dark grayish-brown, or dark grayish-brown silt loam or silty clay loam. The C horizon is silt loam or silty clay loam. The depth to the clay or silty clay IIC horizon ranges from 32 inches to more than 40 inches. In some places below a depth of 24 inches the substratum is glacial till of clay loam texture.

Perella soils are near Doran soils and are similar to Tiffany soils. They are more poorly drained than Doran soils. They contain more clay and less sand than Tiffany soils.

Perella loam, moderately deep over clay (0 to 1 percent slopes) (Pr).—This soil is on broad flats and in slight depressions and swales on the lake plain and the Sheyenne Delta. Areas are small to medium in size and irregular in shape.

Included with this soil in mapping are some areas of Galchutt soils. Also included are areas where the depth to clay or silty clay is more than 40 inches.

This Perella soil has a profile similar to that described as representative of the series, but the surface layer is loam and the subsoil and underlying material, to a depth of about 24 to 40 inches, are loam or silt loam. Below that depth the substratum is silty clay or clay.

This soil is poorly drained. Runoff is slow. Permeability is moderate in the upper part of the profile and slow in the clayey substratum. The hazard of erosion is slight. Some areas of this soil are ponded in spring and in periods of heavy rainfall.

This soil is well suited to farming if excess water is removed. Most areas are used for crops. The main concerns of management are removing excess water and maintaining fertility. Capability unit IIw-6; Wet Meadow range site; windbreak suitability group 2.

Perella silty clay loam, moderately deep over clay (0 to 1 percent slopes) (Ps).—This soil is in shallow depressions and swales and on flats on the lake plain. Areas are small to medium in size and irregular in shape. This soil has the profile described as representative of the series. Included in mapping are small areas of Galchutt soils.

This Perella soil is poorly drained. Runoff is slow, and some areas are ponded in spring and in periods of heavy rainfall. Permeability is moderately slow in the upper part of the profile and slow in the clayey substratum. The hazard of erosion is slight.

This soil is well suited to farming if excess water is removed. Most areas are used for crops. The main concerns of management are removing excess water and maintaining fertility. Capability unit IIw-6; Wet Meadow range site; windbreak suitability group 2.

Figure 18.—**Profile of Renshaw loam. This soil is shallow over coarse sand and gravel.**

Renshaw Series

The Renshaw series consists of shallow, somewhat excessively drained, nearly level to hilly soils on beach ridges and outwash plains. These soils formed in medium-textured alluvium underlain by coarse sand and gravel.

In a representative profile (fig. 18) the surface layer is black loam about 11 inches thick. The subsoil is friable dark-brown loam about 7 inches thick. The underlying material is dark grayish-brown coarse sand and gravel.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying sand and gravel. The available water capacity is low. The organic-matter content is moderate, and fertility is low. Runoff is medium to slow.

The milder slopes of Renshaw soils are suited to farming. The hilly soils are better suited to pasture than to cultivated crops. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops. Some are in pasture.

The Renshaw soils in this survey area are mapped only with Fordville and Sioux soils.

Representative profile of Renshaw loam in an area of Fordville-Renshaw loams, in a cultivated field, 150 feet east and 1,770 feet south of the northwest corner of sec. 35, T. 129 N., R. 48 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; weak, fine, granular structure; friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

B2—11 to 18 inches, dark-brown (10YR 3/3) loam; brown (10YR 5/3) when dry; moderate, medium, prismatic structure; friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

IIC—18 to 60 inches, dark grayish-brown (10YR 4/2) coarse sand and gravel; grayish brown (10YR 5/2) when dry; single grained; loose; mildly alkaline; slight effervescence.

Thickness of the solum and the depth to sand and gravel ranges from 10 to 20 inches. The A horizon is black or very dark gray and is 4 to 12 inches thick. The B horizon is very dark gray, very dark grayish brown, dark grayish brown, or dark brown and is 6 to 12 inches thick.

Renshaw soils formed in the same kind of material as Arvilla, Fordville, and Sioux soils. They contain less sand and more clay in the solum than Arvilla soils. They have a thinner solum over sand and gravel than Fordville soils. They have a thicker solum over sand and gravel than Sioux soils.

Roliss Series

The Roliss series consists of deep, very poorly drained, nearly level, calcareous soils in depressions and swales in the lake plain and the glacial till plain. These soils formed in a thin mantle of alluvium or lacustrine sediments and the underlying medium textured or moderately fine textured glacial till.

In a representative profile the surface layer is black clay loam about 14 inches thick. The subsoil is very dark gray, firm clay loam about 5 inches thick. The underlying material is gray clay loam mottled with dark yellowish brown and yellowish brown.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is very slow. The water table is at the surface or within a depth of 3 feet.

Roliss soils are suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of these soils have been drained and are used for crops.

Representative profile of Roliss clay loam in a cultivated field, 0.8 mile east and 200 feet south of the northwest corner of sec. 4, T. 129 N., R. 47 W.

Ap—0 to 8 inches, black (10YR 2/1) clay loam; very dark gray (10YR 3/1) when moist; weak, medium, subangular blocky structure; friable, sticky and plastic; neutral; slight effervescence; abrupt, smooth boundary.

A12—8 to 14 inches, black (10YR 2/1) clay loam; very dark gray (10YR 3/1) when dry; moderate, medium, subangular blocky structure; friable, sticky and plastic; neutral; slight effervescence; clear, irregular boundary.

B2g—14 to 19 inches, very dark gray (5Y 3/1) clay loam; gray (5Y 5/1) when dry; few, coarse, prominent, dark yellowish-brown (10YR 4/4) mottles; strong, fine, angular blocky structure; firm, sticky and plastic; neutral; slight effervescence; gradual, wavy boundary.

C1g—19 to 30 inches, gray (5Y 5/1) clay loam; light gray (5Y 7/1) when dry; many, medium, prominent, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, subangular blocky structure; firm, sticky and plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C2g—30 to 60 inches, gray (5Y 5/1) clay loam; gray (5Y 6/1) when dry; many, medium, prominent, yellowish-brown (10YR 5/6) and dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; firm, sticky and plastic; mildly alkaline; strong effervescence; common, soft lime segregations.

The solum ranges from 12 to 20 inches in thickness. The A horizon is black or very dark gray and is 8 to 16 inches thick. The B horizon is very dark gray, dark gray, very dark grayish brown, or grayish brown. The C horizon is loam or clay loam.

Roliss soils formed in the same kind of material as Vallers soils. They contain less lime in the upper part of the profile than Vallers soils.

Roliss clay loam (0 to 1 percent slopes) (Ro).—This soil is on the lake plain and glacial till plain in swales and shallow depressions that are small to medium in size and irregular in shape.

This soil is very poorly drained. Runoff is very slow, and the soil is frequently ponded in spring and in periods of heavy rainfall. Permeability is moderately slow. The hazard of erosion is slight.

This soil is suited to farming if excess water is removed. Undrained, it is better suited to hay and pasture than to most other uses. Most areas of this soil have been drained and are used for crops. The main concerns in management are removing excess water and maintaining fertility. Capability unit IIIw-6; Subirrigated range site; windbreak suitability group 2.

Ryan Series

The Ryan series consists of deep, poorly drained, nearly level, fine-textured soils on the lake plain. These soils have a claypan. They are plane and concave. They formed in fine-textured lacustrine sediments.

In a representative profile the surface layer is very dark gray silty clay loam about 5 inches thick. The subsoil is silty clay about 12 inches thick. The upper part is very dark brown. The lower part is very dark gray and contains a large amount of sodium and magnesium salts. The underlying material, to a depth of 23 inches, is dark grayish-brown silty clay. Below this is olive-gray silty clay mottled with light olive brown.

Permeability is very slow. The available water capacity is moderate because the soil is saline. The organic-matter content is high, and fertility is low. Runoff is very slow.

Ryan soils are poorly suited to farming. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops.

Representative profile of Ryan silty clay loam in an area of Ryan-Fargo complex, in a cultivated field, 325 feet west and 2,270 feet south of the northeast corner of sec. 29, T. 134 N., R. 48 W.

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay loam; dark gray (10YR 4/1) when dry; moderate, very fine, granular structure; friable, sticky and plastic; neutral; abrupt, smooth boundary.

B21t—5 to 12 inches, very dark brown (10YR 2/2) silty clay; very dark gray (10YR 3/1) when dry; dark-gray (10YR 4/1) coats on ped faces; moderate, medium, columnar structure parting to strong, fine, angular blocky; firm, very sticky and very plastic; mildly alkaline; clear, smooth boundary.

B22tsa—12 to 17 inches, very dark gray (10YR 3/1) silty clay; dark gray (10YR 4/1) when dry; strong, very fine, subangular blocky structure; firm, very sticky and very plastic; mildly alkaline; slight effervescence; common, fine salt crystals; clear, wavy boundary.

C1—17 to 23 inches, dark grayish-brown (2.5Y 4/2) silty clay; gray (N 5/0) when dry; moderate, very fine, angular blocky structure; firm, sticky and plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C2gcs—23 to 33 inches, olive-gray (5Y 4/2) silty clay; light olive gray (5Y 6/2) when dry; moderate, very fine, angular blocky structure; firm, sticky and plastic; mildly alkaline; strong effervescence; many gypsum crystals; gradual, wavy boundary.

C3g—33 to 60 inches, olive-gray (5Y 4/2) silty clay; light olive gray (5Y 6/2) when dry; many, medium, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, fine, angular blocky structure; firm, very sticky and very plastic; moderately alkaline; strong effervescence; common, soft lime segregations and few gypsum crystals.

The A horizon is black or very dark gray silty clay loam, silty clay, or clay 2 to 5 inches thick. In some places there is an A2 horizon ¼ inch to 2 inches thick. The B2 horizon is black, very dark brown, very dark gray, or very dark grayish-brown clay or silty clay 5 to 12 inches thick. Accumulations of salt are in the lower part of the B2 horizon. The C horizon is clay or silty clay that contains accumulations of salt, gypsum, and lime.

Ryan soils are associated with Aberdeen and Fargo soils and they are similar to Exline soils. They have a thinner A horizon and contain salts at a lesser depth than Aberdeen soils. They have a thinner A horizon and contain a larger concentration of sodium salts in the B horizon than Fargo soils. They are more poorly drained and contain more clay than Exline soils.

Ryan-Fargo complex (0 to 1 percent slopes) (Ry).—This mapping unit is on the lake plain in broad flats that are medium to large in size and irregular in shape. It is about 20 to 50 percent Ryan silty clay loam, about 40 to 65 percent Fargo silty clay, and about 5 to 15 percent Enloe and Aberdeen soils. The Ryan soil has the profile described as representative of the series.

The Ryan and Fargo soils are poorly drained. Runoff is very slow, and some areas are ponded in spring and in periods of heavy rainfall. Permeability is slow in the Fargo soil and very slow in the Ryan soil. These soils are difficult to work and to keep in good tilth. The claypan subsoil of the Ryan soil has been mixed with the surface layer in tillage. Consequently, this layer becomes very sticky when wet and very hard and crusted as it dries. The hazard of soil blowing is moderate.

This soil is suited to farming, and most areas are used for crops. The main concerns in management are maintaining tilth and fertility, removing excess water, and preventing soil blowing. Capability unit IIIs-P4. Ryan soil in Thin Claypan range site and windbreak suitability group 9, Fargo soil in Clayey range site and windbreak suitability group 1.

Serden Series

The Serden series consists of deep, excessively drained, nearly level to hilly soils on low hummocks and dunes on the Sheyenne Delta (fig. 19). These soils formed in wind-sorted fine sands.

In a representative profile the surface layer is black loamy fine sand about 3 inches thick. The next layer is very dark brown fine sand about 5 inches thick. The underlying material, to a depth of 60 inches, is dark grayish-brown fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low, and fertility is low.

Serden soils are too sandy for cultivation. They are suited to hay and pasture. Limitations for many nonfarm uses are moderate to severe. Nearly all areas of these soils are used for pasture and hay.

Representative profile of Serden loamy fine sand in a native grass pasture, 375 feet south and 65 feet west of the northeast corner of sec. 4, T. 135 N., R. 51 W.

A1—0 to 3 inches, black (10YR 2/1) loamy fine sand; very dark gray (10YR 3/1) when dry; moderate, fine, crumb structure; very friable; neutral; clear, smooth boundary.

AC—3 to 8 inches, very dark brown (10YR 2/2) fine sand; dark grayish brown (10YR 4/2) when dry; single grained; loose; neutral; clear, smooth boundary.

C—8 to 60 inches, dark grayish-brown (10YR 4/2) fine sand; grayish brown (10YR 5/2) when dry; single grained; loose; neutral.

The A horizon is black, very dark gray, or dark-gray loamy fine sand or fine sand 1 to 4 inches thick. The AC horizon is very dark brown, very dark grayish-brown, dark grayish-brown, or dark-brown fine sand or loamy fine sand 3 to 8 inches thick.

Serden soils formed in the same kind of material as Maddock soils. They have a thinner A horizon than those soils.

Serden loamy fine sand (0 to 20 percent slopes) (Sd).—This soil is on low hummocks and dunes on the Sheyenne Delta. Areas are small to large in size and irregular in shape. This soil has the profile described as representative of the series. Included in mapping are small areas of Maddock, Hamar, and Venlo soils.

This Serden soil is excessively drained. Runoff is very slow, and permeability is rapid. The hazard of soil blowing is very severe.

This soil is suited to hay and pasture. It is not suited to crops because it is highly susceptible to soil blowing. Most areas of this soil are used for grazing. The main concern in management is maintaining a permanent plant cover of native grasses to help prevent soil blowing and to provide forage for livestock. Capability unit VIIe-TSa; Thin Sands range site; windbreak suitability group 10.

Serden-Stabilized dune land complex (3 to 20 percent slopes) (Se).—This mapping unit is on low hummocks and dunes on the Sheyenne Delta. It is about 70 percent Serden loamy fine sand or fine sand, about 20 percent Stabilized dune land, and 10 percent Maddock, Hamar, and Venlo soils. Areas are medium to large in size and irregular in shape.

Stabilized dune land consists of loose sand that the wind has formed into hummocks and dunes and that has been recently stabilized by various types of plant cover. These are also small blowouts.

These soils are rapidly permeable. Runoff is slow, and the hazard of soil blowing is very severe.

These soils are suited to grazing and hay. They are not suited to crops because the hazard of soil blowing is severe. Most areas are used for grazing. The main concern in management is maintaining a permanent plant cover of native grasses to help prevent soil blowing and to provide forage for livestock. Capability unit VIIe-TSa; Thin Sands range site; windbreak suitability group 10.

Sioux Series

The Sioux series consists of shallow, excessively drained, nearly level to hilly soils on beach ridges and

Figure 19.—Low dunes on the Sheyenne Delta. The sandy Serden soils are in this area.

outwash plains. These soils formed in a thin layer of moderately coarse textured alluvium underlain by coarse sand and gravel.

In a representative profile the surface layer is black sandy loam about 8 inches thick. The next layer is very dark grayish-brown loamy coarse sand about 4 inches thick. The underlying material, to a depth of 60 inches, is dark grayish-brown coarse sand and gravel.

Permeability is rapid to a depth of about 12 inches and is very rapid below. The available water capacity is very low. The organic-matter content is low, and fertility is low. Runoff is slow.

Sioux soils are suited to hay and pasture. They are poorly suited to crops because available water capacity is low. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for pasture and hay. Some areas are in crops.

Representative profile of Sioux sandy loam in an area of Sioux-Renshaw complex, undulating, in a cultivated field, 135 feet north and 145 feet west of the southeast corner of sec. 27, T. 129 N., R. 48 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; dark gray (10YR 4/1) when dry; weak, fine, granular structure; very friable; neutral; clear, smooth boundary.

AC—8 to 12 inches, very dark grayish-brown (10YR 3/2) loamy coarse sand; dark grayish brown (10YR 4/2) when dry; single grained; loose; mildly alkaline; clear, wavy boundary.

IIC—12 to 60 inches, dark grayish-brown (10YR 4/2) coarse sand and gravel; grayish brown (10YR 5/2) when dry; single grained; loose; mildly alkaline.

Thickness of the solum and the depth to sand and gravel range from 7 to 14 inches. The A horizon is black or very dark gray loam, sandy loam, or gravelly loam.

Sioux soils are associated with Renshaw soils, and they formed in the same kind of material as Arvilla and Fordville soils. They are shallower over coarse sand and gravel than any of those soils.

Sioux-Renshaw complex, undulating (0 to 6 percent slopes) (ShB).—This mapping unit is on low hills and ridges on the lake plain and the glacial till plain. It is about 60 percent Sioux sandy loam and about 40 percent Renshaw loam. Areas are small to medium in size and irregular in shape. Most areas are undulating, but some are nearly level. Included in mapping are areas of Sioux soils that have a surface layer of gravelly loam or loam.

The Sioux soil has the profile described as representative of the series. Both soils are shallow over coarse sand and gravel.

The Sioux soil is excessively drained, and the Renshaw soil is somewhat excessively drained. Permeability is moderately rapid in the upper part of these soils and

very rapid in the sand and gravel substratum. Runoff is slow. The available water capacity is low. The hazard of soil blowing is moderate to severe.

These soils are suited to hay and pasture. They are not suited to crops because the available water capacity is low. Some areas are used for crops, and some are used for hay and grazing. The main concerns in management are establishing and maintaining a permanent plant cover of grasses to help prevent erosion and to provide forage for livestock. Capability unit VIs-VS. Sioux soil in Very Shallow range site and windbreak suitability group 10, Renshaw soil in Shallow to Gravel range site and windbreak suitability group 6.

Sioux-Renshaw complex, hilly (6 to 25 percent slopes) (ShE).—This mapping unit is on side slopes and ridges on the glacial till plain. It is about 70 percent Sioux sandy loam or gravelly loam and about 30 percent Renshaw loam. Areas are small to medium in size and irregular in shape. Most areas are hilly, but some areas are rolling. Both soils are shallow over coarse sand and gravel.

The Sioux soil is excessively drained, and the Renshaw soil is somewhat excessively drained. Permeability is moderately rapid in the upper part of these soils and very rapid in the sand and gravel substratum. Runoff is slow. The available water capacity is low. The hazard of soil blowing is severe.

These soils are suited to hay and pasture. They are not suited to crops because the available water capacity is low and the hazard of erosion is severe. Most areas are in native grass hay or pasture, but some areas are used for crops. The main concerns in management are establishing and maintaining a permanent plant cover of grasses to help prevent erosion and to provide forage for livestock. Capability unit VIs-VS. Sioux soil in Very Shallow range site and windbreak suitability group 10, Renshaw soil in Shallow to Gravel range site and windbreak suitability group 10.

Stirum Series

This series consists of deep, poorly drained, nearly level soils on flats and in shallow depressions in the Sheyenne Delta. These soils formed in moderately coarse lacustrine sediments.

In a representative profile the surface layer is black loam about 7 inches thick. The subsoil, about 20 inches thick, is grayish-brown, strongly calcareous friable sandy clay loam that contains a large amount of sodium salts. The underlying material, to a depth of about 46 inches, is fine sandy loam. The upper part of this underlying material is grayish brown mottled with light olive brown, and the lower part is light olive gray mottled with light olive brown. Below a depth of 46 inches is light olive-gray loamy fine sand mottled with light olive brown and yellowish brown.

Permeability is moderately slow in the surface layer and subsoil and moderately rapid in the underlying material. The available water capacity is low. The organic-matter content is high, and fertility is low.

Stirum soils are suited to crops, but they are better suited to hay and pasture than to most other uses. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops, but some are used for hay and pasture.

Representative profile of Stirum loam in an area of Stirum-Arveson loams, in a cultivated field, 85 feet north and 855 feet east of the southwest corner of sec. 10, T. 134 N., R. 52.

Ap—0 to 7 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; moderately alkaline; slight effervescence; abrupt, smooth boundary.

B2ca—7 to 27 inches, grayish-brown (2.5Y 5/2) sandy clay loam; light gray (2.5Y 7/1) when dry; moderate, coarse, prismatic structure parting to weak, medium and coarse, subangular blocky; friable, sticky and plastic; strongly alkaline; strong effervescence; clear, smooth boundary.

C1cag—27 to 30 inches, grayish-brown (2.5Y 5/2) fine sandy loam; light gray (N 7/0) when dry; few, medium, distinct, light olive-brown (2.5Y 5/6) mottles; friable, slightly sticky and slightly plastic; strongly alkaline; strong effervescence; clear, wavy boundary.

C2g—30 to 46 inches, light olive-gray (5Y 6/2) fine sandy loam; light gray (5Y 7/2) when dry; many, large, distinct, light olive-brown (2.5Y 5/6) mottles; weak, coarse, subangular blocky structure; very friable, moderately alkaline; slight effervescence; gradual, wavy boundary.

C3g—46 to 60 inches, light olive-gray (5Y 6/2) loamy fine sand; light gray (5Y 7/2) when dry; many, large, distinct, light olive-brown (2.5Y 5/6) and many, large, prominent, yellowish-brown (10YR 5/4) mottles; single grained; loose; moderately alkaline; slight effervescence.

The solum ranges from 16 to 30 inches in thickness. The A horizon is very dark gray or black loam or fine sandy loam 4 to 13 inches thick. The B horizon is very dark gray, dark-gray, gray, very dark grayish-brown, dark grayish-brown, grayish-brown, or olive-gray fine sandy loam, loam, or sandy clay loam. The C horizon is very fine sandy loam, fine sandy loam, loamy fine sand, or fine sand. In some places layers of finer textured materials are below a depth of 40 inches.

Stirum soils are associated with Arveson soils. They contain more exchangeable sodium and less calcium carbonate than those soils.

Stirum-Arveson loams (0 to 1 percent slopes (Sr).—This mapping unit is in shallow depressions and on broad flats on the Sheyenne Delta. It is about 60 percent Stirum loam, about 30 percent Arveson loam, and 10 percent Borup soils. Areas are small to medium in size and irregular in shape.

The Stirum soil has the profile described as representative of the series. It has a high level of sodium salts in the subsoil. The Arveson soil has a profile similar to that described as representative of the series, but the surface layer is loam.

These soils are poorly drained. Runoff is slow, and the water table is close to the surface in spring and in periods of heavy rainfall. The Stirum soil has moderately slow permeability in the subsoil and moderately rapid permeability in the underlying material. Permeability in the Arveson soil is moderately rapid. If the surface layer is left bare and dry, the hazard of soil blowing is moderate.

These soils are suited to farming, but the sodium salts in the Stirum soil adversely affect crop growth and vigor. Some areas are used for crops, and some are used for hay and grazing. The main concerns in management are removing excess water, preventing soil blowing, reducing the salinity in the Stirum soil, and

maintaining fertility. Capability unit IIIws-4L. Stirum soil in Subirrigated range site and windbreak suitability group 9, Arveson soil in Wet Meadow range site and windbreak suitability group 2.

Strongly Saline Land

Strongly saline land (0 to 3 percent slopes) (St) is on flats on the lake plain and the Sheyenne Delta. It consists of soils that contain such a high level of salts that only the most persistent of salt-tolerant plants can grow. In most areas the source of the high salinity is seepage and overflow from artesian wells. Areas are small in size and irregular in shape.

This land is suited to hay, grazing, and wildlife habitat. It is too salty for cultivated crops. Most areas either have a sparse growth of salt-tolerant grasses and herbs or are bare of vegetation. The main concerns in management are establishing and maintaining a permanent stand of salt-tolerant plants and reducing the salt content. Capability unit VIs-SL; not assigned to a range site; windbreak suitability group 10.

Svea Series

The Svea series consists of deep, moderately well drained, nearly level to undulating soils on the glacial till plain. These soils are plane and slightly concave. They formed in medium textured and moderately fine textured glacial till.

In a representative profile the surface layer is black loam about 11 inches thick. The subsoil is loam about 16 inches thick. The upper part is very dark gray, the middle part is very dark grayish brown, and the lower part is dark grayish brown. The underlying material, to a depth of about 50 inches, is light olive-brown loam. Below this is light olive-brown loam mottled with yellowish brown.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow.

Svea soils are well suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Svea loam in a cultivated field, 375 feet east and 230 feet south of the northwest corner of sec. 27, T. 131 N., R. 52 W.

Ap—0 to 6 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, crumb; friable, slightly sticky and slightly plastic; neutral; abrupt, smooth boundary.

A12—6 to 11 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when dry; weak, medium, subangular blocky structure parting to weak, fine, crumb; friable, slightly sticky and slightly plastic; neutral; clear, smooth boundary.

B21—11 to 15 inches, very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; friable, sticky and plastic; neutral; gradual, wavy boundary.

B22—15 to 20 inches, very dark grayish-brown (2.5Y 3/2) loam; dark grayish brown (2.5Y 4/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; friable, sticky and plastic; neutral; gradual, wavy boundary.

B23—20 to 27 inches, dark grayish-brown (2.5Y 4/2) loam; grayish brown (2.5Y 5/2) when dry; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; friable, sticky and plastic; neutral; clear, wavy boundary.

C1ca—27 to 34 inches, light olive-brown (2.5Y 5/3) loam; light yellowish brown (2.5Y 6/3) when dry; weak, medium, subangular blocky structure; friable, sticky and plastic; mildly alkaline; violent effervescence; few soft lime segregations; gradual, wavy boundary.

C2—34 to 50 inches, light olive-brown (2.5Y 5/3) clay loam; light yellowish brown (2.5Y 6/3) when dry; massive; friable, sticky and plastic; mildly alkaline; strong effervescence; gradual, wavy boundary.

C3—50 to 60 inches, light olive-brown (2.5Y 5/3) loam; light yellowish brown (2.5Y 6/3) when dry; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The solum ranges from 16 to 34 inches in thickness. The A horizon is black or very dark gray and is 8 to 16 inches thick. The B horizon is very dark gray, very dark brown, very dark grayish-brown, or dark grayish-brown loam or clay loam. The C horizon is loam or clay loam.

Svea soils are associated with Barnes, Buse, and Gardena soils and they formed in the same kind of material as Aastad soils. They are dark colored to a greater depth and are not so well drained as Barnes and Buse soils. They differ from Buse soils in having a B horizon. They contain more clay and more coarse fragments than Gardena soils. They contain less clay in the B horizon than Aastad soils.

Svea loam (0 to 3 percent slopes) (Su).—This soil is on the till plain. Areas are small to medium in size and irregular in shape. This soil has the profile described as representative of the series. Included in mapping are small areas of Tonka, Hamerly, Barnes, and Aastad soils.

This Svea soil is moderately well drained. Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. Runoff is slow. The hazard of erosion is slight.

This soil is well suited to farming, and most areas are used for crops. The main concerns in management are conserving water and maintaining fertility. Capability unit IIc-6; Overflow range site; windbreak suitability group 1.

Svea-Buse loams, undulating (3 to 6 percent slopes) (SvB).—This mapping unit is on low knolls, in intervening swales, and on flats on the till plain. It is about 60 percent Svea loam, about 30 percent Buse loam, and 10 percent Barnes, Hamerly, and Tonka soils. Areas are small to medium in size and irregular in shape. The Buse soil is on the light-colored hilltops, and the Svea soil is on the intervening swales and lower parts of knolls.

The Svea soil is moderately well drained, and the Buse soil is well drained. Permeability in the Svea soil is moderate in the surface layer and subsoil and moderately slow in the underlying material. The Buse soil has moderately slow permeability. Runoff is medium, and the hazard of erosion is moderate.

These soils are well suited to farming, and most areas are used for crops. The main concerns in management are conserving water, preventing erosion, and maintaining fertility. Capability unit IIe-6. Svea soil in Silty range site and windbreak suitability group 1, Buse

soil in Thin Upland range site and windbreak suitability group 8.

Svea-Buse loams, rolling (6 to 9 percent slopes) (SvC).—This mapping unit is on the tops and sides of low hills and in intervening swales in the till plain. It is about 50 percent Svea loam, about 35 percent Buse loam, and 15 percent Barnes, Hamerly, and Tonka soils. Areas are small to medium in size and irregular in shape. The Buse soil is on the light-colored hilltops and upper parts of hillsides, and the Svea soil is on lower parts of hillsides and in swales.

The Svea soil is moderately well drained, and the Buse soil is well drained. Permeability in the Svea soil is moderate in the surface layer and subsoil and moderately slow in the underlying material. The Buse soil has moderately slow permeability. Runoff is rapid, and the hazard of erosion is severe.

These soils are suited to farming. Most areas are used for crops, but some are used for hay and pasture. The main concerns in management are preventing erosion, conserving water, and maintaining fertility. Capability unit IIIe-6. Svea soil in Silty range site and windbreak suitability group 1, Buse soil in Thin Upland range site and windbreak suitability group 8.

Svea-Gardena loams (0 to 3 percent slopes) (Sw).—This mapping unit is on broad flats on the southwestern part of the lake plain where a thin mantle of lacustrine sediments overlies glacial till. It is about 50 percent Svea loam, about 40 percent Gardena loam, and 10 percent Barnes soils. Areas are medium to large in size and irregular in shape.

The Gardena soil has a profile similar to that described as representative of the series, but in places it is underlain by loam or clay loam glacial till below a depth of 40 inches.

These soils are moderately well drained. Permeability of the Svea soil is moderate in the surface layer and subsoil and moderately slow in the underlying material. The Gardena soil has moderate permeability. Runoff is slow, and the hazard of erosion is slight.

These soils are well suited to farming, and most areas are used for crops. The main concerns in management are conserving water and maintaining fertility. Capability unit IIc-6. Svea soil in Overflow range site and windbreak suitability group 1, Gardena soil in Silty range site and windbreak suitability group 1.

Swenoda Series

The Swenoda series consists of deep, moderately well drained, nearly level soils on the lake plain, the Sheyenne Delta, and the sand-mantled till plain. These soils are plane and slightly concave. They formed in a thin layer of moderately coarse textured material and the underlying glacial till or lacustrine sediments.

In a representative profile the surface layer is black fine sandy loam about 14 inches thick. The subsoil is very dark grayish-brown, very friable fine sandy loam about 12 inches thick. The underlying material, to a depth of about 35 inches, is grayish-brown silt loam that contains a large amount of lime. Below this is light olive-brown silt loam mottled with dark brown.

Permeability is moderately rapid in the upper part of the profile and moderately slow in the underlying material. The available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow.

Swenoda soils are suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops.

Representative profile of Swenoda fine sandy loam in an area of Towner and Swenoda fine sandy loams, in a cultivated field, 1,440 feet north and 175 feet west of the southeast corner of sec. 17, T. 129 N., R. 49 W.

Ap—0 to 7 inches, black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, fine, granular structure; very friable; neutral; abrupt, smooth boundary.

A12—7 to 14 inches, black (10YR 2/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, coarse, subangular blocky structure parting to weak, medium, granular; very friable; neutral; gradual, wavy boundary.

B2—14 to 26 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; grayish brown (10YR 5/2) when dry; weak, coarse, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

IIC1ca—26 to 35 inches, grayish-brown (2.5Y 5/2) silt loam; light gray (2.5Y 7/2) when dry; massive; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

IIC2—35 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; pale yellow (2.5Y 7/4) when dry; common, medium, prominent, dark-brown (10YR 3/3) mottles; massive; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

Thickness of the solum and the depth to the IIC horizon range from 24 to 36 inches. The A horizon is black or very dark gray and is 12 to 18 inches thick. The B horizon is very dark brown, very dark grayish brown, or dark grayish brown. Mottles of brown or dark brown are in the lower part of the B horizon in some places. The IIC horizon is silt loam, silty clay loam, or silty clay lacustrine sediments, or glacial till of loam or clay loam texture.

Swenoda soils are associated with Towner and Wyndmere soils. They have less sand in the upper part of the profile, above the IIC horizon, than Towner soils. They contain less lime in the upper part of the profile than Wyndmere soils. They are shallower over a medium-textured, moderately fine textured, or fine-textured IIC horizon than Wyndmere soils.

Swenoda-Wyndmere fine sandy loams (0 to 3 percent slopes) (Sy).—This mapping unit is on the Sheyenne Delta and the lake plain in broad flats that are small to large in size and irregular in shape. It is about 50 percent Swenoda fine sandy loam, about 40 percent Wyndmere fine sandy loam, and 10 percent Towner and Kratka soils.

The Swenoda and Wyndmere soils have profiles similar to those described as representative of their respective series, but the material below a depth of about 30 inches ranges from loam to clay.

The Swenoda soil is moderately well drained, and the Wyndmere soil is somewhat poorly drained. Runoff is slow. Permeability is moderately rapid in the upper part of these soils and moderately slow or slow in the substratum. The hazard of soil blowing is severe.

These soils are suited to farming, and most areas are used for crops. The main concerns in management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIIe-3M; Sandy range site; windbreak suitability group 1.

Tiffany Series

The Tiffany series consists of deep, poorly drained, nearly level soils on flats and in shallow depressions on the lake plain and the Sheyenne Delta. These soils formed in moderately coarse textured lacustrine sediments.

In a representative profile the surface layer is about 17 inches thick. The upper 7 inches is black loam, and the lower 10 inches is very dark gray fine sandy loam mottled with dark brown and very dark grayish brown. The next 17 inches is dark grayish-brown fine sandy loam mottled with dark brown. The underlying material to a depth of 46 inches is light olive-brown fine sandy loam mottled with very dark brown and dark yellowish brown. Below this is mixed light olive-brown and grayish-brown fine sandy loam mottled with dark brown.

Permeability is moderately rapid, and the available water capacity is moderate or high. The organic-matter content is high, and fertility is medium. Runoff is slow. The water table is within 1 to 3 feet of the surface in periods of heavy rainfall. In some areas Tiffany soils are underlain by clay below a depth of 24 inches. Permeability in these soils is moderately rapid in the upper part of the profile and slow in the clay substratum.

Tiffany soils are well suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some are in hay and pasture.

Representative profile of Tiffany loam in a cultivated field, 2,560 feet east and 225 feet south of the northwest corner of sec. 16, T. 132 N., R. 50 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky structure parting to weak, fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—7 to 17 inches, very dark gray (10YR 3/1) fine sandy loam; gray (10YR 5/1) when dry; common, fine, faint, dark-brown (10YR 3/3) mottles; weak, medium, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

AC—17 to 34 inches, dark grayish-brown (2.5Y 4/2) fine sandy loam; grayish brown (2.5Y 5/2) when dry; many, fine, faint, dark-brown (10YR 3/3) mottles; weak, coarse and medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

C1g—34 to 46 inches, light olive-brown (2.5Y 5/4) fine sandy loam; light yellowish brown (2.5Y 6/3) when dry; common, fine, prominent, very dark brown (10YR 2/2) and dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

C2g—46 to 60 inches, light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) fine sandy loam; light yellowish brown (2.5Y 6/3) and light brownish gray (2.5Y 6/2) when dry; many, fine, prominent, dark-brown (7.5YR 4/4) mottles; massive; very friable; neutral.

The A horizon is 8 to 24 inches thick and is loam, very fine sandy loam, or fine sandy loam. The C horizon is fine sandy loam, very fine sandy loam, loam, or light silt loam. In places a IIC horizon of clay or silty clay is below a depth of 24 inches.

Tiffany soils are associated with Embden and Glyndon soils and are similar to Perella soils. They are more poorly drained and more mottled than Embden soils. They are more poorly drained and contain less lime than Glyndon soils. They contain less clay and more sand than Perella soils.

Tiffany fine sandy loam (0 to 1 percent slopes) (Td).—This soil is on the Sheyenne Delta in shallow depressions that are small to medium in size and irregular in shape. It has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam. Included in mapping are small areas of Embden and Wyndmere soils.

This Tiffany soil is poorly drained. Runoff is slow. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Permeability is moderately rapid. If the surface layer is left bare and dry, the hazard of soil blowing is severe.

This soil is suited to farming, but excess water is a limitation. Most areas are used for crops. Some are used for hay and pasture. The main concerns in management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIIwe-3; Subirrigated range site; windbreak suitability group 2.

Tiffany loam (0 to 1 percent slopes) (Tf).—This soil is in shallow depressions and broad swales in the Sheyenne Delta. Areas are small to medium in size and irregular in shape. This soil has the profile described as representative of the series. Included in mapping are small areas of Embden and Wyndmere soils.

This Tiffany soil is poorly drained. Runoff is slow. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Permeability is moderately rapid. If the surface layer is left bare and dry, the hazard of soil blowing is moderate.

This soil is suited to farming, but excess water is a limitation. Most areas are used for crops, but some are used for hay and pasture. The main concerns in management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIw-6; Subirrigated range site; windbreak suitability group 2.

Tiffany loam, moderately deep over clay (0 to 1 percent slopes) (Th).—This soil is in shallow depressions and on broad flats on the lake plain and the Sheyenne Delta. Areas are small to medium in size and irregular in shape. This soil has a profile similar to that described as representative of the series, but the underlying material below a depth of about 24 to 36 inches is silty clay or clay. Included in mapping are small areas of Galchutt soils.

This Tiffany soil is poorly drained. Runoff is slow, and some areas are occasionally ponded. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Permeability is moderately rapid in the upper part of the profile and slow in the clayey substratum. If the surface layer is left bare and dry, the hazard of soil blowing is moderate.

This soil is suited to farming, but excess water is a limitation. Most areas are used for crops, but some are used for hay and pasture. The main concerns in management are removing excess water, preventing soil blowing, and maintaining fertility. Capability unit IIw-6; Subirrigated range site; windbreak suitability group 2.

Figure 20.—**Profile of Tonka silt loam showing black surface layer and lighter colored subsurface layer, subsoil, and underlying material.**

Tonka Series

The Tonka series consists of deep, poorly drained, nearly level soils in shallow depressions on the lake plain and the glacial till plain. These soils formed in medium-textured or moderately fine textured alluvium or lacustrine sediments.

In a representative profile (fig. 20) the surface layer is black silt loam about 12 inches thick. The subsurface layer is very dark gray silt loam about 15 inches thick. The subsoil is very dark gray, firm silty clay loam about 11 inches thick. The underlying material is olive-gray silt loam mottled with dark yellowish brown and dark brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow, and these soils are frequently ponded.

Tonka soils are well suited to farming if excess water is removed. Undrained areas are well suited to hay and pasture. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some are in hay and pasture.

Representative profile of Tonka silt loam in a cultivated field, 700 feet south and 85 feet east of the northwest corner of sec. 9, T. 131 N., R. 51 W.

A1p—0 to 7 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky structure parting to moderate, fine, granular; friable, slightly sticky and slightly plastic; slightly acid; abrupt, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; moderate, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; slightly acid; clear, wavy boundary.

A2—12 to 27 inches, very dark gray (10YR 3/1) silt loam; gray (10YR 6/1) when dry; moderate, fine, platy structure; very friable, slightly sticky and slightly plastic; medium acid; gradual, wavy boundary.

B2t—27 to 38 inches, very dark gray (10YR 3/1) silty clay loam; gray (10YR 5/1) when dry; moderate, coarse, prismatic structure parting to strong, medium and fine, angular blocky structure; firm, sticky and plastic; slightly acid; gradual, wavy boundary.

Cg—38 to 60 inches, olive-gray (5Y 5/2) silt loam; light gray (5Y 7/2) when dry; common, medium, prominent, dark yellowish-brown (10YR 3/4) and dark-brown (7.5YR 4/4) mottles; massive; friable, slightly sticky and slightly plastic; neutral; slight effervescence.

The A1 horizon is black or very dark gray silt loam or silty clay loam 6 to 18 inches thick. The A2 horizon is very dark gray, dark-gray, or gray silt loam or silty clay loam 4 to 18 inches thick. The B horizon is black, very dark gray, dark-gray, very dark grayish-brown, or dark grayish-brown silty clay loam, clay loam, or clay. The C horizon is silt loam, silty clay loam, clay loam, silty clay, or clay.

Tonka soils are associated with Parnell soils. They differ from those soils in having an A2 horizon.

Tonka silt loam (0 to 1 percent slopes) (Tk).—This soil is on the glacial till plain in shallow depressions that are small to medium in size and irregular in shape. It has the profile described as representative of the series. Included in mapping are small areas of Hamerly, Parnell, and Vallers soils.

This Tonka soil is poorly drained. Runoff is slow, and it frequently ponds in spring and in periods of heavy rainfall. Permeability is slow. The hazard of soil blowing is slight.

This soil is well suited to farming if excess water is removed. Some areas are used for crops, and some are used for hay and pasture. The main concerns in management are removing excess water and maintaining fertility. Capability unit IIw-6; Wet Meadow range site; windbreak suitability group 2.

Towner Series

The Towner series consists of deep, moderately well drained, nearly level sandy soils on the Sheyenne Delta and the sand-mantled till plain. These soils are plane and slightly convex. They formed in a layer of loamy sand deposited by wind or water over medium-textured to fine-textured glacial till or lacustrine sediments.

In a representative profile the surface layer is loamy fine sand about 17 inches thick. The upper 8 inches is

black and the lower 9 inches is very dark grayish brown. The underlying material, to a depth of about 28 inches, is dark grayish-brown loamy fine sand. Below this is grayish-brown and light olive-brown silt loam.

Permeability is rapid in the sandy upper part of the profile and moderately slow to slow in the underlying material. The available water capacity is moderate or high. The organic-matter content is high, and fertility is medium. Runoff is slow.

Towner soils are suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops. Some are in hay and pasture.

Representative profile of Towner loamy fine sand in a cultivated field, 230 feet north and 215 feet west of the southeast corner of sec. 15, T. 136 N., R. 51 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand; very dark gray (10YR 4/1) when dry; weak, medium and fine, subangular blocky structure parting to weak, fine, granular; very friable; neutral; abrupt, smooth boundary.

A12—8 to 17 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; dark grayish brown (10YR 4/2) when dry; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

C1—17 to 28 inches, dark grayish-brown (10YR 4/2) loamy fine sand; grayish brown (10YR 5/2) when dry; few, fine, faint, dark yellowish-brown (10YR 3/4) mottles in lower part; single grained; loose; neutral; clear, wavy boundary.

IIC2ca—28 to 40 inches, grayish-brown (2.5Y 5/2) silt loam; light gray (2.5Y 7/2) when dry; moderate, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

IIC3—40 to 60 inches, light olive-brown (2.5Y 5/3) silt loam; pale yellow (2.5Y 7/3) when dry; common, fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon is black, very dark gray, very dark brown, or very dark grayish-brown fine sandy loam or loamy fine sand 16 to 24 inches thick. The C horizon is loamy fine sand, loamy sand, or fine sand. The depth to the IIC horizon ranges from 24 to 36 inches. The IIC horizon is glacial till of loam or clay loam texture or lacustrine sediments of silt loam, silty clay loam, silty clay, or clay.

Towner soils are associated with Swenoda soils, and they formed in the same kind of material as Dickey soils. They contain more sand in the upper part of the profile, above the IIC horizon, than Swenoda soils. They are dark colored to a greater depth and are not so well drained as Dickey soils.

Towner loamy fine sand (0 to 3 percent slopes) (To).—This soil is on the Sheyenne Delta on broad flats that are small to medium in size and irregular in shape. It has the profile described as representative of the series. Included in mapping are small areas of Dickey soils that have undulating slopes.

This Towner soil is moderately well drained. Runoff is slow. Permeability is rapid in the upper part of the profile and moderately slow in the lower part. The hazard of soil blowing is very severe.

This soil is suited to farming if soil blowing is controlled. Some areas of this soil are used for crops, and some are used for hay and pasture. The main concerns in management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IVe-2; Sands range site; windbreak suitability group 1.

Towner and Swenoda fine sandy loams (0 to 3 percent slopes) (Tw).—This mapping unit is on the Sheyenne Delta and the lake plain on broad flats that are small to medium in size and irregular in shape. Some areas are Towner fine sandy loam, some are Swenoda fine sandy loam, and some areas are both soils. Included in mapping are areas of Swenoda soils that have a substratum of silty clay loam, silty clay, or clay.

The Towner soil has a profile similar to that described as representative of the series, but the surface layer is fine sandy loam. In places the substratum is silty clay loam, silty clay, or clay. The Swenoda soil has the profile described as representative of the series.

These soils are somewhat poorly drained. Runoff is slow. Permeability in the Towner soil is rapid in the upper part and moderately slow or slow in the substratum. Permeability in the Swenoda soil is moderately rapid in the upper part and moderately slow or slow in the substratum. The hazard of soil blowing is severe.

These soils are suited to farming, and most areas are used for crops. The main concerns in management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIIe-3M; Sandy range site; windbreak suitability group 1.

Ulen Series

The Ulen series consists of deep, somewhat poorly drained, nearly level, sandy soils on the Sheyenne Delta. These soils are plane and slightly convex. They formed in coarse-textured lacustrine deposits.

In a representative profile the surface layer is fine sandy loam about 16 inches thick. The upper 7 inches is black, and the lower 9 inches is very dark gray. The underlying material, to a depth of about 30 inches, is dark-gray loamy fine sand. Below this is grayish-brown and light olive-brown fine sand mottled with yellowish brown and dark reddish brown.

Permeability is rapid, and the available water capacity is low or moderate. The organic-matter content is high, and fertility is medium. Runoff is slow.

Ulen soils are suited to farming. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some are in hay and pasture.

Representative profile of Ulen fine sandy loam in a cultivated field, 2,500 feet east and 270 feet south of the northwest corner of sec. 9, T. 135 N., R. 50 W.

Ap—0 to 7 inches, black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) when dry; weak, medium, granular structure; very friable; mildly alkaline; strong effervescence; abrupt, smooth boundary.

A1ca—7 to 16 inches, very dark gray (10YR 3/1) fine sandy loam; dark gray (10YR 4/1) when dry; weak, medium and fine, subangular blocky structure; very friable; mildly alkaline; violent effervescence; gradual, wavy boundary.

C1ca—16 to 30 inches, dark-gray (10YR 4/1) loamy fine sand; gray (10YR 5/1) when dry; weak, medium, subangular blocky structure; very friable; mildly alkaline; strong effervescence; clear, wavy boundary.

C2—30 to 46 inches, grayish-brown (2.5Y 5/2) fine sand; light gray (2.5Y 7/2) when dry; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; single grained; loose; mildly alkaline; slight effervescence; gradual, wavy boundary.

C3—46 to 60 inches, light olive-brown (2.5Y 5/3) fine sand; pale yellow (2.5Y 7/3) when dry; common, fine,

distinct, yellowish-brown (10YR 5/6) and dark reddish-brown (5YR 2/2) mottles; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is 10 to 16 inches thick and is fine sandy loam or loamy fine sand. The C horizon is loamy fine sand or fine sand. In places, strata of silt loam, silty clay loam, silty clay, or clay are below a depth of 40 inches.

Ulen soils are associated with Hamar soils, and they formed in the same kind of material as Fossum soils. They contain more lime than Hamar soils. They are better drained than Fossum soils.

Ulen fine sandy loam (0 to 3 percent slopes) (Un).—This soil is on the Sheyenne Delta on broad flats that are small to medium in size and irregular in shape. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Hecla and Hamar soils. Also included are small areas where the surface layer is loamy fine sand.

This Ulen soil is somewhat poorly drained. Runoff is slow. Permeability is rapid. The hazard of soil blowing is severe.

This soil is suited to farming, and most areas are used for crops. The main concerns in management are preventing soil blowing, conserving water, and maintaining fertility. Capability unit IIIe-3; Sandy range site; windbreak suitability group 1.

Vallers Series

The Vallers series consists of deep, poorly drained, nearly level soils on flats and in shallow depressions and swales on the glacial till plain and the lake plain. These soils have a zone of lime accumulation within 16 inches of the surface. They formed in medium-textured or moderately fine textured glacial till.

In a representative profile the surface layer is black clay loam about 9 inches thick. The underlying material, to a depth of about 18 inches, is strongly calcareous, dark-gray clay loam. Below this is olive-gray clay loam mottled with dark yellowish brown and yellowish brown.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. Runoff is slow. The water table is within 1 to 3 feet of the surface during periods of heavy rainfall.

Vallers soils are suited to farming if excess water is removed. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some are used for hay and pasture.

Representative profile of Vallers clay loam in a cultivated field, 2,425 feet east and 140 feet south of the northwest corner of sec. 4, T. 129 N., R. 47 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam; dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure; friable, sticky and plastic; mildly alkaline; slight effervescence; abrupt, smooth boundary.

C1ca—9 to 18 inches, dark-gray (2.5Y 4/1) clay loam; gray (2.5Y 5/1) when dry; weak, medium, subangular blocky structure; friable, sticky and plastic; mildly alkaline; violent effervescence; common, fine, soft lime segregations; gradual, wavy boundary.

C2gca—18 to 34 inches, olive-gray (5Y 5/2) clay loam; light olive gray (5Y 6/2) when dry; common, fine, prominent, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; firm, sticky and plastic; mildly alkaline; violent effervescence; common, fine, soft lime segregations; gradual, wavy boundary.

C3g—34 to 60 inches, olive-gray (5Y 5/2) clay loam; light olive gray (5Y 6/2) when dry; many, medium, prominent, yellowish-brown (10YR 5/6) and dark yellowish-brown (10YR 4/4) mottles; massive; firm, sticky and plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray clay loam or silty clay loam 8 to 16 inches thick. The zone of lime accumulation is within a depth of 16 inches, in the lower part of the A horizon or in the upper part of the C horizon. The C horizon is loam or clay loam.

Vallers soils formed in the same kind of material as Hamerly and Roliss soils. They are more poorly drained and have mottles at a lesser depth than Hamerly soils. They contain more lime in the upper part of the profile than Roliss soils.

Vallers clay loam (0 to 1 percent slopes) (Va).—This soil is on broad flats and in depressions on the glacial till plain and lake plain. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Tonka, Parnell, and Hamerly soils.

This Vallers soil is poorly drained. Runoff is slow, and the water table is near the surface in spring and in periods of heavy rainfall. Permeability is moderately slow. If the surface is left bare and dry, the hazard of soil blowing is moderate.

This soil is suited to farming, but excess water is a limitation. Some areas are used for crops, and some are used for hay and pasture. The main concerns in management are removing excess water and maintaining fertility. Capability unit IIw-4L; Wet Meadow range site; windbreak suitability group 2.

Venlo Series

The Venlo series consists of deep, very poorly drained, nearly level sandy soils in depressions and swales on the Sheyenne Delta. These soils formed in coarse-textured lacustrine sediments.

In a representative profile the surface layer is black fine sandy loam about 13 inches thick. The underlying material, to a depth of about 30 inches, is olive-gray fine sand. Below this is olive-gray fine sand mottled with yellowish brown.

Permeability is rapid, and the available water capacity is low. The organic-matter content is high, and fertility is low. The water table is at or near the surface most of the time.

Venlo soils are suited to pasture. They are too wet for cultivation unless drained, but outlets generally are not available. Limitations for many nonfarm uses are severe. Nearly all areas of these soils are used for pasture.

Representative profile of Venlo fine sandy loam in a native grass pasture, 360 feet south and 240 feet west of the northeast corner of sec. 18, T. 135 N., R. 51 W.

A1—0 to 13 inches, black (N 2/0) fine sandy loam; dark gray (N 4/0) when dry; weak, fine, granular structure; very friable; neutral; clear, wavy boundary.

C1g—13 to 30 inches, olive-gray (5Y 5/2) fine sand; light gray (5Y 7/2) when dry; loose; single grained; neutral; gradual, wavy boundary.

C2g—30 to 60 inches, olive-gray (5Y 5/2) fine sand; light gray (5Y 7/2) when dry; many, medium, prominent, yellowish-brown (10YR 5/6) and (10YR 5/8) mottles; loose; single grained; neutral.

The A horizon is loam, fine sandy loam, or loamy fine sand 6 to 18 inches thick. The C horizon is fine sand or loamy fine sand. In places, strata of silt loam, silty clay loam, silty clay, or clay are below a depth of 40 inches.

Venlo soils formed in the same kind of material as Hamar soils. They are more poorly drained than Hamar soils.

Venlo fine sandy loam (0 to 1 percent slopes) (Ve).—This soil is on the Sheyenne Delta, in depressions and swales that are small in size and irregular in shape. Included in mapping are small areas of Arveson and Hamar soils.

This Venlo soil is very poorly drained. The water table is at or near the surface during most of the growing season. Permeability is rapid.

Nearly all areas are in native grass and are used for pasture or hay. The soil is too wet for cultivated crops unless drained, and satisfactory outlets generally are not available. The soil is suited to pasture and hay. Capability unit Vw-WL; Wetland range site; windbreak suitability group 2.

Wahpeton Series

The Wahpeton series consists of deep, moderately well drained, fine-textured soils on bottom lands and terraces along the Red River and its tributaries. These soils formed in clayey alluvium.

In a representative profile the surface layer is black silty clay about 19 inches thick. The subsoil, about 15 inches thick, is very dark grayish-brown friable silty clay. The underlying material, to a depth of 60 inches, is dark grayish-brown silty clay.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is high. Runoff is slow. The soils are occasionally flooded in spring and early in summer.

Wahpeton soils are well suited to farming. Limitations for many nonfarm uses are severe. Most areas of these soils are used for crops. Some areas are in pasture, and some are in native woods.

Representative profile of Wahpeton silty clay in a wooded area, 3,400 feet east and 250 feet south of the northwest corner of sec. 5, T. 135 N., R. 48 W.

A11—0 to 5 inches, black (10YR 2/1) silty clay; very dark gray (10YR 3/1) when dry; strong, very fine, granular structure; friable, sticky and plastic; neutral; clear, wavy boundary.

A12—5 to 19 inches, black (10YR 2/1) silty clay; dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure parting to strong, very fine, granular; friable, sticky and plastic; neutral; gradual, wavy boundary.

B2—19 to 34 inches, very dark grayish-brown (2.5Y 3/2) silty clay; grayish brown (2.5Y 5/2) when dry; weak, medium, prismatic structure parting to moderate, very fine, angular blocky; friable, sticky and plastic; neutral; gradual, wavy boundary.

C—34 to 60 inches, dark grayish-brown (2.5Y 4/2) silty clay; light brownish gray (2.5Y 6/2) when dry; moderate, medium, angular blocky structure; friable, sticky and plastic; neutral; slight effervescence; few soft lime masses.

The A horizon is black or very dark gray clay or silty clay 14 to 30 inches thick. The B horizon is very dark brown or very dark grayish-brown silty clay or clay. The C horizon is silty clay or clay. In many places, the A horizon of a buried soil is below a depth of 36 inches.

Wahpeton soils are associated with LaDelle soils, and they formed in the same kind of material as Cashel and Nutley soils. They contain more clay than LaDelle soils. They have a thicker, darker colored A horizon than Cashel soils and are flooded less frequently. They have a thicker, darker colored A horizon and are not so well drained as Nutley soils.

Wahpeton silty clay (0 to 3 percent slopes) (Wa).—This soil is on low terraces and bottom land along the Red River and its tributaries. Areas are medium in size and irregular in shape. This soil has the profile described as representative of the series. Included in mapping are small areas of Cashel soils.

This Wahpeton soil is moderately well drained. Permeability is moderately slow. Runoff is slow. Some areas are occasionally flooded in spring and early in summer when streams are at high flood stage. The hazard of erosion is slight.

This soil is well suited to farming, and most areas are used for crops. Some areas are in native woods. The main concerns in management are maintaining tilth and fertility and the hazard of flooding. Capability unit IIs-4; Clayey range site; windbreak suitability group 1.

Wet Alluvial Land

Wet alluvial land (0 to 3 percent slopes) (We) is on low bottom lands and in swales. Areas are small to medium in size and irregular in shape. The soil material ranges from sandy loam to clay. The upper part is black and is high in organic-matter content.

This land is very poorly drained and is frequently flooded. The water table is at or near the surface during most of the growing season.

Wet alluvial land is suited to pasture. It is too wet for hay or crops. Most of the acreage is used for grazing. Capability unit Vw-WL; Wetland range site; windbreak suitability group 10.

Wyndmere Series

The Wyndmere series consists of deep, somewhat poorly drained, nearly level soils on the Sheyenne Delta. These soils are plane and slightly convex and have a zone of lime accumulation within 16 inches of the surface. They formed in moderately coarse textured and coarse textured lacustrine sediments.

In a representative profile the surface layer is fine sandy loam about 15 inches thick. The upper 8 inches is black, and the lower 7 inches is very dark gray and is strongly calcareous. The underlying material, to a depth of about 26 inches, is gray fine sandy loam that contains a large amount of lime. Below this is light olive-brown fine sandy loam mottled with dark reddish brown, very dark brown, and yellowish brown.

Permeability is moderately rapid, and the available water capacity is moderate or high. The organic-matter content is high, and fertility is high. Runoff is slow.

Wyndmere soils are suited to farming. Limitations for many nonfarm uses range from slight to severe. Most areas of these soils are used for crops. Some are in hay and pasture.

Representative profile of Wyndmere fine sandy loam, in a cultivated field, 455 feet east and 190 feet north of the southwest corner of sec. 9, T. 133 N., R. 49 W.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam; very dark gray (10YR 3/1) when dry; weak, coarse, subangular blocky structure parting to moderate, medium, granular; very friable; moderately alkaline; slight effervescence; abrupt, smooth boundary.

A12ca—8 to 15 inches, very dark gray (10YR 3/1) fine sandy loam; gray (10YR 5/1) when dry; very weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; very friable; moderately alkaline; strong effervescence; gradual, wavy boundary.

C1ca—15 to 26 inches, gray (10YR 5/1) fine sandy loam; light gray (10YR 6/1) when dry; weak, coarse, prismatic structure parting to weak, coarse, subangular blocky; very friable; moderately alkaline; violent effervescence; gradual, wavy boundary.

C2—26 to 44 inches, light olive-brown (2.5Y 5/3) fine sandy loam; pale yellow (2.5Y 7/3) when dry; few, fine, distinct, dark reddish-brown (5YR 3/2) mottles; weak, coarse, subangular blocky structure; very friable; moderately alkaline; strong effervescence; gradual, wavy boundary.

C3—44 to 60 inches, light olive-brown (2.5Y 5/3) fine sandy loam; pale yellow (2.5Y 7/3) when dry; many, fine, prominent, very dark brown (10YR 2/2) and yellowish-brown (10YR 5/6) mottles; massive; very friable; moderately alkaline; strong effervescence.

The A horizon is fine sandy loam or loam 7 to 15 inches thick. The C horizon is fine sandy loam to a depth of about 36 inches. Below 36 inches the substratum ranges from fine sand to clay.

Wyndmere soils are associated with Embden, Glyndon, and Swenoda soils. They contain more fine and coarse sand than Glyndon soils. They contain more lime to a depth of 16 inches than Embden and Swenoda soils.

Wyndmere fine sandy loam (0 to 3 percent slopes) (Wy).—This soil is on the Sheyenne Delta and the lake plain in broad flats that are small to medium in size and irregular in shape. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Embden and Tiffany soils. Also included are some small areas of moderately saline soils.

This Wyndmere soil is somewhat poorly drained. Permeability is moderately rapid. Runoff is slow. The hazard of soil blowing is severe.

This soil is well suited to farming, and most areas are used for crops. The main concerns in management are preventing soil blowing, maintaining fertility, and conserving water. Capability unit IIIe-3; Sandy range site; windbreak suitability group 1.

Zell Series

The Zell series consists of deep, well-drained, rolling to steep soils on slopes and breaks along streams that dissect the Sheyenne Delta and the lake plain. These soils formed in silty lacustrine sediments.

In a representative profile the surface layer is black silt loam about 7 inches thick. The underlying material, to a depth of 34 inches, is grayish-brown silt loam. Below this is light olive-brown silt loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate, and fertility is medium. Runoff is rapid.

The milder slopes of the Zell soils are suited to farming. The hilly and steep soils are better suited to pasture than to cultivated crops. Limitations for many nonfarm uses range from slight to severe. Most areas of the milder sloping soils are used for crops. Most hilly and steep areas are in pasture.

Representative profile of Zell silt loam in an area of Zell-Eckman silt loams, steep, in a native grass pasture, 2,600 feet east and 200 feet north of the southwest corner of sec. 32, T. 136 N., R. 51 W.

A1—0 to 7 inches, black (10YR 2/1) silt loam; dark gray (10YR 4/1) when dry; moderate, medium and fine, granular structure; very friable, slightly sticky and slightly plastic; neutral; clear, wavy boundary.

C1ca—7 to 34 inches, grayish-brown (2.5Y 5/2) silt loam; light brownish gray (2.5Y 6/2) when dry; weak, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; mildly alkaline; violent effervescence; gradual, wavy boundary.

C2—34 to 60 inches, light olive-brown (2.5Y 5/3) silt loam; light yellowish brown (2.5Y 6/3) when dry; massive; friable, slightly sticky and slightly plastic; mildly alkaline; strong effervescence.

The A horizon is black or very dark gray and is 4 to 12 inches thick. In places there is an AC horizon that is very dark grayish brown, dark grayish brown, dark brown, or brown. The C horizon is loam, very fine sandy loam, or silt loam.

Zell soils are associated with Eckman soils. They do not have the B horizon that is typical of Eckman soils.

Zell-Eckman silt loams, hilly (9 to 12 percent slopes) (ZeD).—This mapping unit is on slopes and breaks along streams that flow through the Sheyenne Delta and the lake plain. It is about 50 percent Zell silt loam, about 35 percent Eckman silt loam, and 10 percent LaPrairie and Lamoure soils in narrow swales and drainageways. Areas are small to medium in size and irregular in shape. Included in mapping are small areas of Buse and Egeland soils.

The Zell and Eckman soils are well drained. Permeability is moderate. Runoff is rapid, and the hazard of erosion is severe. The hazard of soil blowing is moderate.

These soils are suited to farming if erosion is controlled. Most areas are used for crops, but some areas are used for hay and pasture. The main concerns in management are preventing erosion, conserving water, and maintaining fertility. Capability unit IVe-6. Zell soil in Thin Upland range site and windbreak suitability group 8, Eckman soil in Silty range site and windbreak suitability group 3.

Zell-Eckman silt loams, steep (12 to 20 percent slopes) (ZeE).—This mapping unit is on breaks and slopes along streams that flow through the Sheyenne Delta and the lake plain. It is about 60 percent Zell silt loam, about 30 percent Eckman silt loam, and 10 percent LaPrairie and Lamoure soils in narrow swales and drainageways. Areas are small to medium in size and irregular in shape. Included in mapping are small areas where the surface layer is loam. The Zell soil has the profile described as representative of the series.

Both soils are well drained. Permeability is moderate. Runoff is rapid, and the hazard of erosion is very severe.

These soils are suited to hay and pasture. They are not suited to cultivated crops because they are steep and the hazard of erosion is severe. Most areas are used for hay and pasture, but some areas are used for crops.

The main concerns in management are establishing and maintaining a permanent plant cover of grasses to help prevent erosion and to provide forage for livestock. Capability unit VIe-TU. Zell soil in Thin Upland range site and windbreak suitability group 8, Eckman soil in Silty range site and windbreak suitability group 8.

Use and Management of the Soils

This section suggests use and management of the soils for crops, range, windbreaks, wildlife, recreation, and engineering. It explains the system of capability classification used by the Soil Conservation Service and shows estimated yields of principal crops.

Management of Crops[3]

About 76 percent of the survey area is cultivated. Corn, soybeans, and spring wheat are the principal crops. Oats and barley are other important crops.

The main considerations in managing cultivated crops in the survey area are conserving moisture, controlling soil blowing and water erosion, and maintaining fertility.

In dryfarmed areas conserving moisture generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Among the effective means are stubble mulching, contour farming, stripcropping, field windbreaks, buffer strips, timely tillage, minimum tillage, use of crop residue, and application of fertilizer. Fallowing helps to control weeds and to build up the moisture content.

Among the measures that help to control erosion are cover crops, stripcropping, buffer strips, windbreaks, contour farming, diversions, waterways, minimum tillage, timely tillage, emergency tillage, and the use of crop residue. Generally, a combination of several measures is used.

Among the measures that help to maintain fertility are the application of chemical fertilizer, green manure and barnyard manure, and the inclusion in the cropping system of cover crops, grasses, and legumes, as well as the use of summer fallow. Controlling erosion helps to conserve fertility.

Removal of excess water and reduction of salinity are needed in places to offset the effects of unfavorable soil characteristics.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, all kinds of soils are grouped at three levels: the capability class, subclass, and unit. These levels are described in the following paragraphs:

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage) ; *s* shows that the soil is limited mainly because it is shallow, droughty, or saline; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry. For some soils, erosion or wetness and one of the other kinds of limitations have about equal importance, and the subclass symbol shows both kinds; IIIes is an example.

Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or range, woodland, wildlife, or recreation.

[3] By EDWARD R. WEIMER, agronomist, Soil Conservation Service.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to be similar in productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about the management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-6 or IIIw-6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral identifies the capability unit within the subclass. Arabic numerals are also used to indicate the susceptibility to wind erosion, ranging from 2, which is very high, to 6, which is slight. The letter *P* indicates the presence of a sodic claypan in the subsoil, and the letter *L* indicates that the soil is calcareous. The letter *M* indicates that the soil is moderately coarse textured or coarse textured to a depth of less than 40 inches and medium textured to fine textured below. Following the subclass designation in capability units in classes V, VI, and VII is an abbreviation of the name of the range site into which the soils of this unit have been placed.

In the following pages the capability units in the survey area are described and suggestions for the use and management of the soils in each unit are given. The units are not numbered consecutively, because not all of the units in the statewide system are represented in this survey area. The capability classification of each individual soil is given in the "Guide to Mapping Units."

CAPABILITY UNIT IIe-4

The one soil in this unit, Fargo silty clay, gently sloping, is a deep, fine-textured soil on side slopes along small streams in the lake plain.

Natural fertility and the organic-matter content are high. The available water capacity is high, permeability is slow, and runoff is medium.

This soil is difficult to work. It is very sticky when wet. It becomes very hard and cloddy unless it is tilled at the proper moisture content. Water erosion and soil blowing are slight hazards. The major management practices needed are those that maintain the levels of organic matter and fertility, control erosion, and keep the soil in good tilth.

This soil is suited to small grain, corn, soybeans, and alfalfa. Legumes and grasses in the crop rotation and the use of crop residue and manure help in maintaining the levels of organic matter and fertility. Summer fallow, minimum tillage, and weed control help in conserving moisture. Use of crop residue and rough tillage reduce the hazards of soil blowing and water erosion. Tillage at the proper moisture content helps keep the soil in good tilth.

CAPABILITY UNIT IIe-4L

This unit consists of deep, nearly level, medium textured and moderately fine textured soils on uplands. In most areas these soils are somewhat poorly drained and near the surface are high in content of lime, but in some areas they are mapped with poorly drained, noncalcareous soils. The water table is seasonally high, and some small areas are occasionally ponded.

The organic-matter content is high. Natural fertility is medium or high. Available water capacity is moderate or high, and permeability ranges from moderately rapid to slow.

These soils are easy to till and easy to keep in good tilth. They are moderately susceptible to blowing. The major management practices needed are those that maintain good tilth and the levels of organic matter and fertility, control erosion, and remove excess water from areas that become ponded during periods of heavy rainfall.

These soils are well suited to small grain, corn, soybeans, alfalfa, and sugar beets. Grass and legumes in the crop rotation and the use of crop residue and manure help in maintaining tilth and the levels of organic matter and fertility. Minimum tillage, stubble mulch tillage, stripcropping, cover crops, buffer strips, and single row tree belts help to prevent soil blowing. Surface drainage is effective if satisfactory outlets are available.

CAPABILITY UNIT IIe-5

This unit consists of deep, nearly level and undulating, medium-textured soils on uplands. In most areas these soils are moderately well drained or well drained, but in some areas they are mapped with poorly drained soils.

The organic-matter content is high, and natural fertility is medium or high. Available water capacity is moderate or high. Permeability is moderate to moderately rapid.

These soils are easy to till and easy to keep in good tilth. They are moderately susceptible to blowing, and the undulating soils are moderately susceptible to water erosion. The major management practices needed are those that maintain the levels of organic matter and fertility, control erosion, and conserve moisture.

These soils are well suited to small grain, corn, soybeans, sugar beets, and alfalfa. Grass in the crop rotation and the use of crop residue and manure help maintain tilth and the levels of organic matter and fertility. Stubble mulch tillage, stripcropping, and cover crops help control erosion. Single row tree belts and buffer strips trap snow, provide additional moisture, and help prevent soil blowing. Weed control and summer fallow help conserve moisture.

CAPABILITY UNIT IIe-6

This unit consists of undulating soils on uplands and channeled soils on stream terraces and bottom lands. These soils are deep and well drained or moderately well drained. They have a medium textured or moderately fine textured surface layer. Some areas are moderately eroded.

The organic-matter content is moderate or high. Natural fertility is high in most of the acreage, but in some small areas it is low. Available water capacity is high. Permeability ranges from moderate to slow.

These soils are easy to till and easy to keep in good tilth. They are moderately susceptible to water erosion and slightly susceptible to blowing. The major management needed maintains organic matter and fertility, controls erosion, and conserves moisture.

These soils are suited to small grain, corn, soybeans, alfalfa, and sugar beets. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and content of organic matter. Minimum tillage, stubble mulch tillage, and cover crops help to control erosion. Single row tree belts and buffer strips help prevent soil blowing and trap snow to provide additional moisture. Summer fallow and weed control help to conserve moisture.

CAPABILITY UNIT IIw-4L

This unit consists of deep, nearly level, poorly drained soils on lake plains, till plains, and bottom lands. These soils have a medium textured or moderately fine textured, calcareous surface layer, and most are shallow over a zone of accumulated lime.

The organic-matter content is high. Natural fertility is medium. The available water capacity in most of these soils is high, but in some it is moderate or low. Permeability ranges from moderately slow to rapid. The water table is within 1 to 3 feet of the surface in spring and in periods of heavy rainfall. Runoff is slow, and some areas are occasionally ponded.

These soils are easy to till, but excess water frequently interferes with tillage. Soil blowing is a moderate hazard if the surface is left bare and dry. The major management needed removes excess water, maintains fertility and organic-matter content, and prevents soil blowing.

If drained, these soils are suited to small grain, corn, soybeans, and alfalfa. Undrained areas are suitable for late crops in dry seasons and for hay and pasture. Surface drainage is effective if satisfactory outlets are available. Use of crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and content of organic matter. Stubble mulch tillage and cover crops help to prevent soil blowing.

CAPABILITY UNIT IIw-6

This unit consists of deep, nearly level soils on flats and in shallow depressions on uplands. These soils are somewhat poorly drained, poorly drained, or very poorly drained. They have a medium textured or moderately fine textured surface layer.

The organic-matter content is high. Natural fertility is medium or high. The available water capacity is moderate or high. Permeability ranges from slow to moderately rapid. Runoff is slow, and these soils are occasionally ponded in periods of heavy rainfall.

These soils are easy to till when dry, but during periods of heavy rainfall they are frequently too wet for cultivation. The major management needed removes excess water and maintains fertility and content of organic matter.

These soils are well suited to small grain, corn, soybeans, and alfalfa if excess water is removed. Surface drainage is effective if satisfactory outlets are available. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility, content of organic matter, and tilth.

CAPABILITY UNIT IIwe-4

This unit consists of deep, nearly level, poorly drained soils on the lake plain. On most of the acreage the surface layer is silty clay, but in some areas soils that have a silty clay loam surface layer are mapped with fine-textured soils.

The organic-matter content is high. Natural fertility is high. The available water capacity is high. Permeability is slow. Runoff is very slow, and the soils are occasionally flooded after heavy rains.

These soils are difficult to till and to keep in good tilth. They are sticky when wet. If tilled when wet, they become hard and cloddy as they dry. They are moderately to highly susceptible to blowing late in winter and early in spring when the surface layer slakes down to sand-sized particles. The major management needed is that necessary to maintain organic-matter content, fertility, and good tilth; remove excess water; and prevent soil blowing (fig. 21).

These soils are suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility, organic-matter content, and tilth. Tillage at the proper moisture content helps to maintain good tilth. Surface drainage is effective if satisfactory outlets are available. Stubble mulch tillage, rough tillage, single-row tree belts, buffer strips, and cover crops help to prevent soil blowing.

CAPABILITY UNIT IIs-4

This unit consists of deep, nearly level, fine-textured soils on stream terraces and bottom lands. These soils are moderately well drained or somewhat poorly drained. In some areas they are occasionally flooded early in spring when streams overflow.

The organic-matter content is moderate or high. Natural fertility is high. Available water capacity is high. Permeability is moderately slow.

These soils are difficult to work and somewhat difficult to keep in good tilth. They are very sticky when wet. If tilled when wet, they become hard and cloddy as they dry. The major management needed maintains organic matter, fertility, and good tilth and conserves moisture.

These soils are suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility, organic-matter content, and tilth. Tillage at the proper moisture content helps to maintain tilth. Summer fallow and weed control help conserve moisture.

CAPABILITY UNIT IIc-6

This unit consists of deep, nearly level, medium textured and moderately fine textured soils on uplands, terraces, and bottom land. In most areas these soils are well drained or moderately well drained, but in some areas they are somewhat poorly drained.

The organic-matter content is high or moderate. Natural fertility is high. Available water capacity is high. Permeability is moderate to slow.

These soils are easy to till and easy to keep in good tilth. The hazards of soil blowing and water erosion are slight. The main limitations are occasional periods of light rainfall and a short growing season. The major management needed maintains organic-matter content, fertility, and tilth and conserves moisture.

Figure 21.—**Land smoothing in an area of Fargo silty clay commonly done to improve surface drainage. This soil is in capability unit IIwe-4.**

These soils are well suited to small grain, corn, soybeans, sugar beets, and alfalfa. Using crop residue and manure and growing grass and legumes in the crop rotation help to improve and maintain fertility, organic-matter content, and tilth. Minimum tillage, summer fallow, and weed control help conserve moisture. Stubble mulch tillage, buffer strips, and single-row tree belts help prevent soil blowing and trap snow to provide additional moisture.

CAPABILITY UNIT IIIe-3

This unit consists of deep, nearly level and undulating, moderately coarse textured soils on uplands. In most areas these soils are well drained, moderately well drained, or somewhat poorly drained. In some areas, however, poorly drained soils are mapped with moderately well drained soils. The surface layer is fine sandy loam or sandy loam.

The organic-matter content is moderate or high. Natural fertility is low, medium, or high. Available water capacity is low or moderate. Permeability is rapid or moderately rapid.

These soils are easy to till and easy to keep in good tilth. They are highly susceptible to blowing. The major management needed maintains the levels of organic matter and fertility, prevents soil blowing, and conserves moisture.

These soils are well suited to small grain, corn, soybeans, sugar beets, and alfalfa. Growing grass and legumes in the crop rotation and using crop residue and manure help to maintain fertility and content of organic matter. Stubble mulch tillage, minimum tillage, stripcropping, and cover crops help prevent soil blowing. Single-row tree belts, buffer strips, and standing stubble help prevent soil blowing and trap snow to provide additional moisture. Weed control helps conserve moisture.

CAPABILITY UNIT IIIe-3M

This unit consists of deep, nearly level and undulating, moderately coarse textured soils on uplands. These soils are well drained, moderately well drained, and somewhat poorly drained. The surface layer is fine sandy loam. The underlying material, below a depth of about 24 inches or more, is loam, clay loam, silty clay loam, or clay.

The organic-matter content is moderate or high. Natural fertility is medium or high. Available water

capacity is moderate. Permeability is rapid or moderately rapid in the upper part and moderate to slow in the underlying material.

These soils are easy to till and easy to keep in good tilth. They are highly susceptible to blowing. The major management needed maintains organic-matter content and fertility, prevents soil blowing, and conserves moisture.

These soils are well suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content. Stubble mulch tillage, minimum tillage, stripcropping, and cover crops help to prevent soil blowing. Single row tree belts, buffer strips, and standing stubble help prevent soil blowing and trap snow to provide additional moisture. Weed control helps to conserve moisture.

CAPABILITY UNIT IIIe-3P

The only soil in this unit, Aberdeen fine sandy loam, is a deep, nearly level, somewhat porly drained soil that has a claypan in the subsoil.

The organic-matter content is high. Natural fertility is medium. The available water capacity is high. Permeability is moderately rapid above the claypan subsoil and slow below.

This soil is easy to till. It is highly susceptible to blowing. The major management needed maintains fertility and organic-matter content, prevents soil blowing, and conserves moisture.

This soil is suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing legumes and grass in the crop rotation help maintain fertility and organic-matter content. Stubble mulch tillage, minimum tillage, stripcropping, cover crops, single-row tree belts, and buffer strips help prevent erosion. Standing stubble, tree belts, and buffer strips trap snow and provide additional moisture. Weed control helps conserve moisture.

CAPABILITY UNIT IIIe-4

The one soil in this unit, Nutley silty clay, rolling, is a deep, well-drained, fine-textured soil on side slopes along streams in the lake plain.

Natural fertility and the organic-matter content are high. Available water capacity is high, and permeability is slow. Runoff is rapid. The hazard of erosion is severe.

This soil is difficult to till and to keep in good tilth. It is sticky when wet. If tilled when wet, it becomes hard and cloddy as it dries. It is moderately susceptible to blowing. The major management needed maintains fertility, organic-matter content, and tilth, controls erosion, and conserves moisture.

This soil is suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing legumes and grasses in the crop rotation help to maintain fertility, organic-matter content, and tilth. Tillage at the proper moisture content helps to maintain good tilth. Stubble mulch tillage, minimum tillage, and cover crops help to control erosion. Summer fallow and weed control help to conserve moisture.

CAPABILITY UNIT IIIe-5

This unit consists of Eckman-Zell silt loams, rolling, a complex of deep, well-drained, medium-textured soils on uplands.

The organic-matter content is moderate or high. Natural fertility is medium to high. Available water capacity is high. Permeability is moderate. Runoff is rapid. These soils are highly susceptible to water erosion and moderately susceptible to blowing. The major management needed maintains fertility and organic-matter content, controls erosion, and conserves moisture.

These soils are easy to till and easy to keep in good tilth. They are suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content. Stubble mulch tillage, minimum tillage, and cover crops help to control erosion. Standing stubble, buffer strips, and single-row tree belts help to prevent soil blowing and trap snow to provide additional moisture. Weed control helps to conserve moisture.

CAPABILITY UNIT IIIe-6

This unit consists of deep, medium-textured, rolling soils on the glacial till plain. These soils are well drained and moderately well drained. Some areas have been moderately eroded.

The organic-matter content is moderate to high. Natural fertility ranges from low to high. Available water capacity is high. Permeability is moderately slow. Runoff is rapid. The soils are highly susceptible to water erosion and slightly susceptible to blowing. The major management needed maintains fertility and organic-matter content, controls erosion, and conserves moisture.

These soils are suited to small grain, alfalfa, and tame grass. They are poorly suited to corn and soybeans because of the erosion hazard. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content. Stubble mulch tillage, minimum tillage, cover crops, and grassed waterways help to control erosion and runoff. Protected summer fallow and weed control help to conserve moisture.

CAPABILITY UNIT IIIes-3

The one soil in this unit, Arvilla fine sandy loam, is a nearly level to gently sloping, somewhat excessively drained soil that is shallow to moderately deep over coarse sand and gravel.

The organic-matter content is moderate. Natural fertility is medium. The available water capacity is low. Permeability is moderately rapid in the upper part of the profile and very rapid in the underlying sand and gravel. The soil is highly susceptible to blowing. The major management needed maintains fertility and organic-matter content, prevents soil blowing, and conserves moisture.

This soil is suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content. Stubble mulch

tillage, minimum tillage, and cover crops help to prevent soil blowing. Single-row tree belts and buffer strips trap snow to provide additional moisture and help prevent soil blowing. Weed control helps to conserve moisture.

CAPABILITY UNIT IIIwe-3

This unit consists of deep, nearly level soils on flats and in shallow depressions on the lake plain and Sheyenne Delta. These soils are poorly drained and somewhat poorly drained. They have a fine sandy loam surface layer.

The organic-matter content is high. Natural fertility is medium. Available water capacity ranges from low to moderate. Permeability in most of the soils is rapid or moderately rapid, but in some of the soils permeability is moderately slow or slow in the underlying material. The water table is within 1 to 3 feet of the surface in periods of heavy rainfall, and some areas are occasionally ponded.

These soils are easy to till when dry. They are highly susceptible to blowing if the surface is left dry and bare. The major management needed removes excess water, prevents soil blowing, and maintains fertility and organic-matter content.

If drained, these soils are well suited to small grain, corn, soybeans, and alfalfa. They are also suited to these crops in undrained areas, but excess water frequently delays seeding and prevents tillage. Drainage is effective if satisfactory outlets are available. Stubble mulch tillage, stripcropping, cover crops, buffer strips, and single-row tree belts help prevent soil blowing. Using crop residue and manure and growing legumes and grass in the crop rotation help to maintain fertility and organic-matter content.

CAPABILITY UNIT IIIw-4

This unit consists of deep, nearly level, very poorly drained, fine-textured soils on the lake plain. The surface layer is silty clay or clay.

The organic-matter content and natural fertility are high. Available water capacity is high. Permeability is slow. The soils are frequently ponded unless they are drained.

These soils are difficult to work and to keep in good tilth. They are very sticky when wet. If tilled when wet, they become hard and cloddy as they dry. The major management needed removes excess water and maintains fertility, organic-matter content, and tilth.

If drained, these soils are suited to small grain, corn, soybeans, and alfalfa. Undrained areas are generally too wet for cultivated crops and are better suited to hay and pasture. Drainage is effective if satisfactory outlets are available. Using crop residue and growing legumes and grass in the crop rotation help to maintain fertility, organic-matter content, and tilth. Tilling at the proper moisture content helps keep this soil in good tilth.

CAPABILITY UNIT IIIw-6

This unit consists of deep, nearly level, very poorly drained, moderately fine textured soils in depressions in the till plain and lake plain.

Natural fertility and organic-matter content are high. Available water capacity is high. Permeability is slow or moderately slow. The soils are frequently ponded unless they are drained.

The major management needed removes excess water and maintains fertility, organic-matter content, and tilth.

If drained, these soils are suited to small grain, corn, soybeans, and alfalfa. Undrained areas are generally too wet for cultivated crops and are better suited to hay and pasture. Surface drainage is effective if satisfactory outlets are available. Using crop residue and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content.

CAPABILITY UNIT IIIws-4L

This unit consists of Stirum-Arveson loams, a complex of two poorly drained, nearly level soils on the Sheyenne Delta. One of these soils contains a large amount of sodium salts, and the other has a shallow zone of lime accumulation.

The organic-matter content is high. Natural fertility is medium in one of these soils and low in the other. Available water capacity is low or moderate. Permeability in one of these soils is moderately slow in the subsoil and rapid in the underlying material. Permeability is moderately rapid in the other soil. The water table is high during periods of heavy rainfall.

These soils are easily tilled when they are dry. They are moderately susceptible to blowing when the surface is left bare and dry. The major management needed removes excess water and maintains fertility and organic-matter content.

If drained, these soils are suited to small grain, corn, soybeans, and alfalfa. They are also suited to these crops in undrained areas, but excess water frequently delays seeding and tillage. Growth and vigor of crops is adversely affected by the high content of sodium salts in the root zone of one of these soils. Drainage is effective if satisfactory outlets are available. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content. Stubble mulch tillage and cover crops help to prevent soil blowing.

CAPABILITY UNIT IIIs-4L

This unit consists of deep, nearly level soils on the lake plain. These soils are moderately well drained and somewhat poorly drained and are moderately saline. They have a silt loam or silty clay loam surface layer. They have soluble salts in the root zone that adversely affect the growth and vigor of crops.

The organic-matter content is high. Natural fertility is medium. Available water capacity is moderate. Permeability in one of the soils is moderate in the upper part of the profile and moderately slow in the underlying material. Permeability in the other soils is moderately slow.

These soils are easy to till and to keep in good tilth. They are moderately susceptible to soil blowing. The main limitation is salinity. The major management needed reduces salinity, maintains fertility and organic-matter content, and prevents soil blowing.

These soils are suited to small grain, corn, soybeans, and alfalfa. Using such deep-rooted legumes as sweet clover or alfalfa lowers the water table and helps to reduce the salinity of the root zone. Using crop residue and manure and growing grass and legumes help to maintain fertility and organic-matter content. Stubble mulch tillage, stripcropping, cover crops, and buffer strips help to prevent soil blowing.

CAPABILITY UNIT IIIs-5

This unit consists of Fordville-Renshaw loams, a complex of nearly level to sloping soils that are underlain by coarse sand and gravel at a depth of 10 to 36 inches. One soil is somewhat excessively drained, and the other is well drained.

The organic-matter content is moderate or high. Natural fertility is medium or low. Available water capacity is low or moderate. Permeability is moderate or moderately rapid in the upper part of the soil and very rapid in the coarse sand and gravel.

These soils are easy to till and to keep in good tilth. They are moderately susceptible to blowing. The major management needed maintains fertility and organic-matter content, prevents soil blowing, and conserves moisture.

These soils are suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing legumes and grass in the crop rotation help to maintain fertility and organic-matter content. Stubble mulch tillage, minimum tillage, and cover crops help control erosion. Single-row tree belts and buffer strips help prevent soil blowing and trap snow to provide additional moisture.

CAPABILITY UNIT IIIs-P4

This unit consists of soils on the lake plain. Some of these soils are very shallow over a dense claypan subsoil. Some do not have a claypan. Others have a pan, but it is below plow depth. All are deep, nearly level, and poorly drained or somewhat poorly drained. They have a silty clay loam or silty clay surface layer. The soils that are very shallow over a claypan are strongly alkaline and contain a large amount of sodium salts in the lower part of the subsoil.

The organic-matter content is high. Natural fertility is low to medium in the soils that have a claypan subsoil and high in the rest. Available water capacity is moderate in the soils that have a very shallow claypan and high in the rest. Permeability is slow or very slow. Runoff is very slow. Some areas of these soils are flooded during periods of heavy rainfall.

These soils are difficult to till and to keep in good tilth. In many places the claypan subsoil is mixed with the plow layer. Where this occurs, the surface layer is very sticky when wet, and it becomes very hard and crusted when dry. Seedbed preparation is very difficult under these conditions. The soils that have a silty clay surface layer are also very sticky when wet and tend to become hard and cloddy unless tilled at the proper moisture content. All are moderately to highly susceptible to blowing late in winter and early in spring, as the silty clay surface layer slakes down into sand-sized particles. The major management needed maintains fertility, organic-matter content, and tilth; prevents soil blowing; and removes excess water from areas that become flooded.

These soils are suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing legumes and grass in the crop rotation help to maintain fertility, organic-matter content, and tilth. Tillage at the proper moisture content helps keep this soil in good tilth. Stubble mulch tillage, rough tillage, buffer strips, and cover crops help to prevent soil blowing. Surface drainage is effective if satisfactory outlets are available.

CAPABILITY UNIT IIIs-P6

This unit consists of deep, nearly level soils on broad flats on the lake plain. These are somewhat poorly drained, medium textured and moderately fine textured soils that have a clay subsoil at a depth of 10 to 24 inches. About half the acreage is a soil that has a silt loam surface layer and a sodic clay subsoil. The rest consists of two soils that have a silty clay loam surface layer. In one of these soils the clay subsoil contains sodium, and in the other soil the subsoil is nonsodic.

The organic-matter content is high. Natural fertility is medium to high. Available water capacity is high. Permeability is moderate in the surface layer and subsurface layer and slow in the clay subsoil.

These soils are easy to till and to keep in good tilth. The hazard of soil blowing is slight. The main limitations are slow permeability and alkalinity of the clay subsoil. The major management needed maintains fertility, organic-matter content, and tilth, prevents soil blowing, and conserves moisture.

These soils are suited to small grain, corn, soybeans, and alfalfa. Using crop residue and manure and growing legumes and grass in the crop rotation help to maintain fertility, organic-matter content, and tilth. Stubble mulch tillage, minimum tillage, and cover crops help to prevent soil blowing. Deep tillage helps to break up the clay subsoil and to increase the intake rate. Summer fallow and weed control help to conserve moisture.

CAPABILITY UNIT IVe-2

This unit consists of deep, nearly level and undulating soils on the Sheyenne Delta. In nearly all of the acreage of this mapping unit the surface layer is loamy fine sand or loamy sand, but a small acreage of soils that have a loam surface layer is mapped with the coarse-textured soils. In most areas these soils are moderately well drained or well drained, but in some places they are mapped with poorly drained and somewhat poorly drained soils.

The organic-matter content is high or moderate. Natural fertility is medium or low. Available water capacity is low or moderate. Permeability is rapid or moderately rapid in all these soils except two. Permeability in these is rapid in the upper part of the profile and moderately slow or slow in the underlying material.

These soils are highly susceptible to soil blowing. The major management needed prevents soil blowing and maintains fertility and organic-matter content.

These soils are suited to small grain, corn, soybeans, and alfalfa. Stubble mulch tillage, minimum tillage,

stripcropping, single-row tree belts, buffer strips, and cover crops help to control soil blowing. Using crop residue and manure and growing legumes and grass in the crop rotation help to maintain fertility and organic-matter content. Fall plowing or summer fallowing greatly increases the hazard of soil blowing.

CAPABILITY UNIT IVe-6

This unit consists of deep, hilly, medium-textured, well-drained soils on uplands. These soils have a loam or silt loam surface layer. Some areas have been moderately eroded.

The organic-matter content is moderate or high. Natural fertility ranges from low to high. Available water capacity is high. Permeability is moderate or moderately slow.

These soils are easy to till and to keep in good tilth. They have rapid runoff and are highly susceptible to erosion. The major management needed controls erosion, maintains fertility and organic-matter content, and conserves moisture.

These soils are suited to small grain, alfalfa, and tame grasses. They are not suited to row crops, because water erosion is a severe hazard. Stubble mulch tillage, minimum tillage, cover crops, and grassed waterways help to control erosion and runoff. Using crop residue and manure and growing grass and legumes in the crop rotation help to maintain fertility and organic-matter content and control erosion. Standing stubble and single-row tree belts trap snow and provide additional moisture.

CAPABILITY UNIT IVwe-2

This unit consists of deep, nearly level soils on the Sheyenne Delta. These coarse-textured soils are somewhat poorly drained and poorly drained. The surface layer is loamy fine sand. In most places the underlying material is loamy fine sand or fine sand, but in some places it is silty clay or clay. The water table is within 20 inches of the surface during periods of heavy rainfall.

The organic-matter content is high. Natural fertility is medium. Available water capacity is low. Most of these soils are rapidly permeable, but those that have a clay substratum are slowly permeable.

These soils are highly susceptible to blowing if they are left bare and dry. The major management needed removes excess water, prevents soil blowing, and maintains fertility and organic-matter content.

If drained, these soils are suited to small grain, corn, soybeans, and alfalfa. They are also suited to these crops in undrained areas, but excess water frequently delays seeding and prevents tillage. Surface drainage is effective if satisfactory outlets are available. Stubble mulch tillage, minimum tillage, cover crops, stripcropping, buffer strips, and single-row tree belts help to prevent soil blowing. Using crop residue and manure and growing legumes and grass in the crop rotation help to maintain fertility and organic-matter content.

CAPABILITY UNIT Vw-WL

This unit consists of deep, nearly level soils in depressions and swales and on low land. These soils are poorly drained and very poorly drained. The water table is at or near the surface most of the time, and shallow water ponds on the surface for a large part of the growing season.

The organic-matter content is high. Natural fertility is low to high. Available water capacity ranges from low to high. Permeability ranges from rapid to slow.

There is no erosion hazard. The major management need is maintaining a good stand of desirable plants that produce high-quality forage for livestock.

These soils are too wet for cultivated crops. They are suited to hay and pasture and to wildlife habitat.

CAPABILITY UNIT VIe-Ov

This unit consists of LaDelle and Wahpeton soils, channeled: two deep, moderately well drained soils on bottom land that have been severely dissected by oxbows and abandoned channels. The surface layer of one of these soils is silty clay loam, and the other is silty clay.

Natural fertility and organic-matter content are high. Available water capacity is high. Permeability is moderate or moderately slow.

These soils are too severely dissected and too irregular in slope to be cultivated. They are suited to pasture or woodland. In most areas they support a stand of native trees, brush, and grasses. They are occasionally flooded in spring when streams overflow. They are moderately susceptible to erosion. The chief management need is to maintain a vegetative cover that produces high-quality forage for livestock and helps to control erosion and runoff. Proper stocking, deferred grazing, proper distribution of grazing, and proper seasonal use help to improve and maintain stands of desirable native plants.

CAPABILITY UNIT VIe-Sa

This unit consists of a deep, well-drained, coarse-textured, rolling soil and two deep, coarse-textured, nearly level soils that have been severely eroded. One of the nearly level, severely eroded soils is moderately well drained, and the other is somewhat poorly drained.

The organic-matter content is moderate to high. Natural fertility is low or medium. Available water capacity is low. Permeability is rapid. The soils are highly susceptible to blowing. The major management need is establishing and maintaining a permanent vegetative cover that produces high-quality forage for livestock and controls soil blowing.

These soils are not suited to cultivated crops because the hazard of soil blowing is severe. They are suited to grazing or hay. Some areas are in native grass, but some have been cultivated and do not have a permanent plant cover. Reseeding with adapted species of tame and native grasses is the first step in establishing a permanent plant cover. Proper stocking, deferred grazing, proper distribution of grazing, and proper seasonal use help to maintain and improve a stand of high-quality grasses.

CAPABILITY UNIT VIe-TU

This unit consists of deep, hilly and steep, medium-textured soils on uplands. These soils are well drained and somewhat excessively drained.

Natural fertility and organic-matter content range from low to high. Available water capacity is high. Permeability is moderate or moderately slow. Runoff is very rapid, and the soils are highly susceptible to erosion.

These soils are not suited to cultivated crops because they are steep and the hazard of erosion is severe. They are suited to pasture or hay. The major management need is maintaining a permanent plant cover of high-quality grasses that help control runoff and erosion and produce high-quality forage for livestock. Most areas are in native grass, but some have been cultivated and do not have a permanent plant cover. Reseeding with adapted tame and native grasses where necessary, proper stocking, proper distribution of grazing, deferred grazing, and proper seasonal use help to improve and maintain a stand of high-quality grasses.

CAPABILITY UNIT VIs-SL

Only Strongly saline land is in this unit. It is on the Sheyenne Delta and the lake plain. It has such a high concentration of soluble salts that only the most salt-tolerant plants can grow. It is nearly level and poorly drained. Most areas occur where seepage and overflow from artesian wells has increased the salinity of the soil.

Strongly saline land is too salty for cultivated crops. It is suited to hay and pasture. The chief management need is maintaining a plant cover that produces forage for livestock. Good range management that includes proper stocking, deferred and rotation grazing, and proper seasonal use help to improve a stand of native grass. Reseeding cultivated areas to adapted species of tame and native grasses helps to improve the plant cover.

CAPABILITY UNIT VIs-TCp

The two soils in this unit, Exline and Ryan soils, are level soils on the lake plain. They are somewhat poorly drained and poorly drained and have a shallow claypan subsoil. The claypan contains a large amount of sodium. These soils have a surface layer of silt loam, silty clay loam, or silty clay.

The organic-matter content is moderate or high. Natural fertility is low. The high salt content keeps available water capacity moderate or low. Permeability is very slow.

The major management need is maintaining a plant cover that produces high-quality forage for livestock.

These soils are not suited to cultivated crops. They are suited to pasture and hay. Some areas are in native grass and some areas are in crops. Good range management that includes proper stocking, deferred and rotation grazing, and proper seasonal use helps to maintain and improve a stand of native grass. Cultivated areas should be reseeded to adapted species of tame and native grasses.

CAPABILITY UNIT VIs-VS

This unit consists of undulating to hilly soils on uplands. These soils are somewhat excessively or excessively drained. They have a loam, sandy loam, or gravelly loam surface layer and are underlain by coarse sand and gravel at a depth of about 7 to 18 inches.

The organic-matter content is low to moderate. Natural fertility is low to medium. Available water capacity is low or very low. Permeability is moderately rapid in the upper part of the soil and very rapid in the coarse sand and gravel.

These soils are highly susceptible to blowing. The chief management need is maintaining a permanent plant cover that produces high-quality forage for livestock.

These soils are not suited to cultivated crops, because available water capacity is low and the root zone is shallow. They are suited to pasture and hay. Reseeding areas now in crops to adapted species of tame and native grass, proper stocking, deferred and rotation grazing, and proper seasonal use help to establish and maintain a stand of high-quality grasses.

CAPABILITY UNIT VIIe-TSa

This unit consists of deep, excessively drained, nearly level to hilly, coarse-textured soils on sandhills on the Sheyenne Delta. These soils have a thin surface layer of loamy fine sand or fine sand.

Natural fertility and organic-matter content are low. Available water capacity is low. Permeability is rapid.

These soils are highly susceptible to blowing. The chief management need is maintaining a plant cover that produces high-quality forage for livestock and controls soil blowing.

These soils are not suited to cultivated crops, because they are highly susceptible to blowing. They are suited to grazing or hay. Most areas are in native grass. Some areas contain blowouts that have been stabilized. Good range management includes proper stocking, deferred grazing, proper distribution of grazing and proper seasonal use that help to maintain and improve a stand of native grasses. Reseeding blowouts to adapted species of tame and native grasses helps to increase forage production. Application of manure or a straw mulch on blowouts helps to protect the soil until newly seeded grasses are established.

CAPABILITY UNIT VIIIw-1

Only Marsh is in this unit. It is made up of shallow lakes and depressions that are wet throughout most of the year. The vegetation is bulrushes, cattails, reeds, and other aquatic plants that have little value as livestock food. Marsh provides excellent habitat for wetland wildlife.

Predicted Yields

Table 2 shows the predicted average yields per acre of the principal crops grown in the survey area under two levels of management. The estimates in columns A are yields to be expected under average management. Those in columns B are yields that can be obtained under the best techniques and management practices available at the present time.

The yields predicted in table 2 are based on records and information furnished by farmers to the Extension Service, the North Dakota Agricultural Experiment Station, and the Soil Conservation Service. These yield predictions are useful to farmers in choosing a suitable

TABLE 2.—*Predicted average acre yields of principal crops*

[Yields in columns A can be expected under average management; those in columns B can be expected under improved management. Absence of a figure indicates that the crop is not suited to the soil. Only arable soils are listed]

Soil	Wheat		Oats		Barley		Soybeans		Corn silage		Corn grain	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Bu*	*Bu*
Aastad-Forman loams	31	41	56	90	41	66	20	29	10.0	16.0	58	90
Aberdeen fine sandy loam	21	29	38	64	27	46	13	19	8.0	12.0	45	70
Aberdeen silt loam	28	38	51	84	36	61	16	24	8.5	15.0	49	75
Aberdeen-Galchutt silty clay loams	30	40	54	88	39	64	16	24	8.5	13.0	49	75
Aberdeen-Ryan silty clay loams	23	32	41	70	30	51	11	16	5.5	9.0	32	50
Antler silty clay loam	26	35	47	77	34	56	13	19	6.5	11.0	39	60
Antler-Tonka silty clay loams [1]	24	33	43	73	31	53	13	19	6.5	11.0	39	60
Arveson-Fossum fine sandy loams [1]	17	24	31	53	22	38	12	16	6.0	7.5	36	45
Arveson and Fossum loams [1]	17	24	31	53	22	38	12	16	6.0	7.5	36	45
Arvilla fine sandy loam	15	18	27	39	20	29	10	14	5.0	6.0	29	35
Barnes-Buse loams, hilly	14	20	25	44	18	32	—	—	—	—	—	—
Barnes-Buse loams, hilly, eroded	12	20	22	44	15	32	—	—	—	—	—	—
Barnes-Svea loams, undulating	30	40	54	88	39	64	17	26	9.0	14.0	52	80
Bearden silty clay loam	33	43	60	95	43	69	17	26	9.0	14.0	52	80
Bearden and Glyndon silt loams, moderately deep over clay	33	43	60	95	43	69	17	26	9.0	14.0	52	80
Borup loam [1]	24	33	43	73	31	53	14	19	7.0	9.0	42	55
Cashel silty clay	28	38	51	84	36	61	17	26	8.5	13.0	49	75
Colvin silty clay loam [1]	24	33	43	73	31	53	13	18	6.5	8.5	39	50
Dickey-Towner fine sandy loams, undulating	18	23	32	52	23	36	13	19	6.5	11.0	39	60
Doran clay loam	30	41	55	89	40	65	16	24	8.5	13.0	49	75
Doran-Perella clay loams [1]	28	38	51	84	36	61	15	22	8.0	12.0	45	70
Doran-Tonka silty clay loams [1]	28	38	51	84	36	61	15	22	8.0	12.0	45	70
Dovray silty clay [1]	24	33	43	73	31	53	13	19	6.5	11.0	39	60
Eckman-Zell silt loams, rolling	19	27	34	59	25	43	11	16	5.5	9.0	32	50
Egeland and Maddock fine sandy loams, undulating	17	21	31	46	22	34	11	16	5.5	8.0	32	47
Embden-Tiffany fine sandy loams	26	35	47	77	34	56	21	30	10.5	17.0	62	95
Embden-Tiffany loams	26	35	47	77	34	56	22	32	11.0	18.0	65	100
Fairdale silt loam	30	40	54	88	39	64	20	29	10.0	16.0	58	90
Fairdale silt loam, channeled	28	38	51	84	36	61	19	27	9.5	15.0	55	85
Fairdale silty clay loam	30	40	54	88	39	64	20	29	10.0	16.0	58	90
Fargo silty clay loam	31	44	56	99	41	70	17	28	8.0	12.0	45	70
Fargo silty clay	31	44	56	99	41	70	17	28	8.0	12.0	45	70
Fargo silty clay, depressional [1]	30	44	54	99	39	70	16	28	7.0	11.5	42	65
Fargo silty clay, gently sloping	28	40	51	88	36	64	16	24	7.0	11.5	42	65
Fargo silty clay, till substratum	30	40	54	88	39	64	15	22	8.0	12.0	45	70
Fargo-Enloe silty clay loams [1]	30	40	54	88	39	64	15	22	8.0	12.0	45	70
Fargo-Enloe complex, till substratum [1]	30	40	54	88	39	64	15	22	8.0	12.0	45	70
Fargo-Hegne silty clays	30	40	54	88	39	64	15	22	8.0	12.0	45	70
Fargo-Hegne silty clays, till substratum	30	42	54	93	39	67	15	22	8.0	12.0	45	70
Fargo-Ryan silty clay loams	24	33	43	73	31	53	12	16	6.0	7.5	36	45
Fargo-Ryan silty clays	24	33	43	73	31	53	12	16	6.0	7.5	36	45
Fordville-Renshaw loams	19	23	34	50	25	36	12	16	6.0	7.5	36	45
Forman-Aastad loams, undulating	30	40	54	88	39	64	17	26	9.0	14.0	52	80
Forman-Aastad loams, undulating, eroded	29	40	52	88	38	64	17	26	9.0	14.0	52	80
Forman-Buse loams, rolling	21	29	38	64	27	46	13	19	6.5	11.0	39	60
Forman-Buse loams, rolling, eroded	20	29	36	64	25	46	13	19	6.5	11.0	39	60
Forman-Peever clay loams, undulating	27	37	48	80	35	58	17	26	9.0	14.0	52	80
Fossum fine sandy loam [1]	17	24	31	53	22	38	12	16	6.0	7.5	36	45
Galchutt silt loam	33	43	60	95	43	69	16	24	8.5	13.0	49	75
Galchutt-Enloe-Fargo complex	30	40	54	88	39	64	15	22	8.0	12.0	45	70
Galchutt-Overly silt loams	33	43	60	95	43	69	17	26	9.0	14.0	52	80
Gardena silt loam	35	45	63	100	46	72	22	32	11.0	18.0	65	100
Gardena-Eckman silt loams, undulating	31	41	56	90	41	66	20	29	10.0	16.0	58	90
Gardena and Embden loams	28	38	51	84	36	61	22	32	11.0	18.0	65	100
Gilby silt loam	28	38	51	84	36	61	17	26	9.0	14.0	52	80
Gilby silt loam, moderately saline	17	22	31	48	22	36	11	14	5.5	7.0	32	40
Gilby and Hamerly loams	28	38	51	84	36	61	17	26	9.0	14.0	52	80
Glyndon silt loam	33	43	60	95	43	69	20	29	10.0	16.0	58	90
Glyndon-Tiffany very fine sandy loams	27	36	49	79	35	58	16	24	8.0	13.0	48	72
Glyndon-Tiffany loams, moderately deep over clay [1]	30	40	55	88	40	64	20	29	10.0	16.0	58	90
Glyndon and Wyndmere loams	24	33	43	73	31	53	20	29	10.0	16.0	58	90
Grano clay [1]	21	29	38	64	27	46	11	15	5.5	7.0	32	40
Hamar loamy fine sand [1]	17	24	31	53	22	38	16	24	8.5	13.0	49	75
Hamar loamy fine sand, moderately deep over clay [1]	17	24	31	53	22	38	16	24	8.5	13.0	49	75

TABLE 2.—*Predicted average acre yields of principal crops*—Continued

	Wheat		Oats		Barley		Soybeans		Corn silage		Corn grain	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Bu*	*Bu*
Hamar fine sandy loam [1]	21	29	38	64	27	46	20	29	10.0	16.0	58	90
Hamar fine sandy loam, moderately deep over clay [1]	21	29	38	64	27	46	20	29	9.0	14.0	52	80
Hamar-Ulen loamy fine sands	17	24	31	53	22	38	15	22	8.0	12.0	45	70
Hamar-Ulen fine sandy loams	21	29	38	64	27	46	19	27	9.5	15.0	55	85
Hamerly loam	28	38	51	84	36	61	17	26	9.0	14.0	52	80
Hecla loamy fine sand, loamy substratum	17	24	31	53	22	38	15	22	8.0	12.0	45	70
Hecla-Hamar loamy fine sands	17	24	31	53	22	38	15	22	8.0	12.0	45	70
Hecla-Hamar fine sandy loams	21	29	38	64	27	46	20	29	10.0	16.0	58	90
Hecla-Hamar-Arveson complex	15	19	27	42	20	30	10	14	5.0	8.0	29	45
Hecla-Maddock loamy sands	15	19	27	43	20	32	13	16	6.5	10.0	39	55
Hecla-Maddock sandy loams	17	24	31	53	22	38	16	24	8.5	13.0	49	75
Kratka fine sandy loam [1]	21	29	38	64	27	46	20	29	9.0	14.0	52	80
LaDelle silty clay loam	35	45	63	100	46	72	20	29	10.0	16.0	58	90
Lamoure silty clay loam [2]	21	29	38	64	27	46	11	16	5.5	9.0	32	50
LaPrairie silt loam	35	45	63	100	46	72	22	32	11.0	18.0	65	100
Maddock-Hecla loamy fine sands, undulating	14	17	25	37	18	27	12	18	6.0	10.0	36	55
Maddock-Hecla-Hamar loamy fine sands, undulating	14	17	25	37	18	27	10	14	5.0	8.0	29	45
Nutley silty clay, rolling	21	29	38	64	27	46	14	21	6.0	10.0	36	55
Overly silty clay loam	35	45	63	100	46	72	20	29	10.0	16.0	58	90
Overly-Bearden silt loams, moderately saline	17	22	31	48	22	36	11	14	5.5	7.0	32	40
Overly-Bearden silty clay loams, moderately saline	17	22	31	48	22	36	11	14	5.5	7.0	32	40
Overly-Beotia silty clay loams, undulating	33	43	60	95	43	69	19	27	9.5	15.0	55	85
Parnell silty clay loam [1,2]	23	32	41	70	30	51	13	19	4.5	6.0	26	35
Parnell and Tonka silty clay loams [1]	26	35	47	77	34	56	14	21	7.0	9.0	42	55
Peever-Forman clay loams	28	38	51	84	36	61	19	27	9.5	15.0	55	85
Perella loam, moderately deep over clay [1]	26	35	47	77	34	56	14	21	7.0	11.5	42	65
Perella silty clay loam, moderately deep over clay [1]	26	35	47	77	34	56	14	21	7.0	11.5	42	65
Roliss clay loam [1]	23	32	41	70	30	51	13	18	6.5	8.0	39	50
Ryan-Fargo complex	20	28	35	60	26	44	11	15	5.5	7.0	32	40
Stirum-Arveson loams	14	18	25	44	18	32	8	11	4.0	5.5	22	30
Svea loam	33	43	60	95	43	69	21	30	10.5	17.0	62	95
Svea-Buse loams, undulating	27	36	49	80	35	58	17	26	9.0	14.0	52	80
Svea-Buse loams, rolling	23	32	41	70	30	51	14	21	7.0	11.5	42	65
Svea-Gardena loams	33	43	60	95	43	69	21	30	10.5	17.0	62	95
Swenoda-Wyndmere fine sandy loams	24	33	43	73	31	53	20	29	10.0	16.0	58	90
Tiffany fine sandy loam [1]	17	24	31	53	22	38	13	19	6.5	11.0	39	60
Tiffany loam [1]	24	33	43	73	31	53	21	30	10.5	17.0	62	95
Tiffany loam, moderately deep over clay [1]	24	33	43	73	31	53	21	30	10.5	17.0	62	95
Tonka silt loam [1]	26	35	47	77	34	56	14	21	7.0	11.5	42	65
Towner loamy fine sand	17	24	31	53	22	38	15	22	8.0	12.0	45	70
Towner and Swenoda fine sandy loams	24	33	43	73	31	53	21	30	10.5	17.0	62	95
Ulen fine sandy loam	21	29	38	64	27	46	17	26	9.0	14.0	52	80
Vallers clay loam [1]	24	33	43	73	31	53	13	17	6.5	8.0	39	50
Wahpeton silty clay	33	43	60	95	43	69	21	30	10.0	16.0	58	90
Wyndmere fine sandy loam	24	33	43	73	31	53	20	29	10.0	16.0	58	90
Zell-Eckman silt loams, hilly	14	20	25	44	18	32	—	—	—	—	—	—

[1] Yields shown are for drained areas.
[2] Drainage is feasible in only a few areas.

cropping sequence or in determining the value of a specified acreage. Practices under high-level management are—

1. Regular application of fertilizer in the kinds and amounts indicated by soil tests that will maintain the supply of plant nutrients at the level suggested by the soil testing laboratory at North Dakota State University.
2. Use of the latest recommended varieties of crops and high quality seed.
3. Regulating the seeding rate so that the greatest number of plants that the available moisture supply can support will be produced.
4. Tilling, seeding, cultivating, and harvesting at the proper time.
5. Effective control of erosion.
6. Draining wet soils by surface drains and controlling flooding where needed.
7. Controlling weeds, insects, and plant diseases by chemicals and cultural practices.

Under average management most of these practices are used, but fertilizer is not applied according to soil tests and wet soils are not adequately drained.

Range[4]

This survey area is at the western edge of the tall grass prairie. Wooded areas occur along the Red River and the Sheyenne and Wild Rice Rivers and their tributaries. The tall grass prairie was found highly suitable for cultivation and consequently only scattered, grass-covered tracts remain.

Approximately 100,000 acres in the survey area is range. Of this acreage, approximately 71,109 acres is in the Sheyenne National Grassland. The Grassland, in the mideastern part of Ransom County and the northwestern part of Richland County, is administered by the Forest Service in cooperation with the Sheyenne Valley Grazing Association. The rest of the acreage in range occurs as small tracts in other parts of the survey area. These scattered tracts are mostly seeped land, poorly drained sloughs, and steep land.

Range is concentrated in soil associations 5 and 6 (see the general soil map) and is dominantly Serden, Maddock, Hecla, Hamar, and Arveson soils. All are sandy soils that have been shaped into dunes and depressions by wind. In the 1930's, blowouts were caused by heavy grazing. Most of these blown out areas, however, are now stabilized with native vegetation. Throughout this sandy area are varying numbers of low-lying meadows or sloughs, which occur as scattered small pockets in the hilly part and as large wet meadows in the less sloping parts. A high water table is characteristic of these low areas, except during extremely dry periods.

The information that follows is based on several years of observations and a limited number of detailed surveys on specific sites by personnel of the Soil Conservation Service, the Forest Service, and North Dakota State University.

Range sites and range condition

Differences in environment throughout a geographic area influence the native plant communities. Most important elements are the kinds of soil, the topography, the moisture regime, the direction of exposure, and the amount of salts or alkali in the soil.

These naturally differing plant communities, as related to the soil and other physical factors, are classified as range sites. Range sites are, therefore, distinctive kinds of range that differ in their potential to produce native vegetation.

Over the years a mixture of plants best adapted to each range site has developed. This group of plants is called the potential, or climax, plant community for the site. If a site is undisturbed, the climax plant community can vary slightly from year to year, but the kinds and numbers of plants remain about the same.

The original mixture of plants is so well adapted to the soil and climate of the range site that other kinds of plants can not move in unless an area is disturbed. So consistent is the relation between plants, climate, and soil that the climax plant community can be closely predicted even where considerable disturbance has occurred, if the soil has been identified.

Range conservationists and soil scientists, working together, group into a range site those soils that naturally grow the same climax plant community.

Plant response to grazing depends on the kind of grazing animal, the season of use, and how closely the plant is grazed. Repeated overgrazing, excessive burning, or plowing result in changes in the kinds, proportions, or amounts of climax plants in the plant community. Depending on the nature and degree of disturbance, some plants increase and others decrease. If disturbance is severe, plants that were not originally part of the climax plant community can invade. Following a disturbance, the climax plant community can be gradually reestablished, under good management, unless the soil has been seriously eroded.

Range condition is the present state of the plant community compared with the potential plant community for the same site. The more closely the present plant community approximates the potential plant community, the better the range condition. The Soil Conservation Service recognizes four condition classes. Range is in *excellent* condition if 76 to 100 percent of the vegetation is characteristic of the climax vegetation on the same site; it is in *good* condition if the percentage is between 51 to 75; in *fair* condition if the percentage is between 26 to 50; and in *poor* condition if the percentage is less than 26.

The present range condition provides an index to change that has taken place in the plant community. More important, range condition is a basis for predicting the kind and amount of change in the present plant community that can be expected under change in management. Thus, the range condition indicates the nature of the present plant community, and the climax cover for the range site represents a goal toward which range management can be directed.

Knowledge of the climax plant communities of range sites and the nature of present plant communities as compared with potential plant communities is important in planning and managing the range. Such information is the basis for selecting management directives, designing grazing systems, managing for wildlife, determining potential for recreation, and rating watershed conditions.

A desirable management objective provides for a plant cover that adequately protects or improves the soil and water resources and meets the needs of the operator. This generally involves maintaining or increasing desirable plants and restoring the plant community to near climax condition in places where it has deteriorated. Sometimes, however, a plant cover somewhat below climax condition better suits specific grazing needs, provides better wildlife habitat, or furnishes other benefits and still protects the soil and water resources.

Management of range

In the following pages, the range sites of the soil survey area are described and the major climax plants are listed for each site. Plant species most likely to increase or invade are also identified. The potential

[4] By HENRY D. GALT and CLAYTON L. QUINNILD, range conservationists, Soil Conservation Service.

annual production of air-dry herbage is estimated for each range site in excellent range condition. This productivity normally fluctuates annually, according to favorableness of the growing season. Annual vegetative production is shown for both above average and below average years. Extreme variations in very dry years or very wet years are not considered.

The range site is designated for each soil in the area in the "Guide to Mapping Units" at the back of this survey.

The seven major range sites described are Wetland, Wet Meadow, Subirrigated, Overflow, Sandy, Sands, and Thin Sands. Minor in the survey area are the Thin Upland, Very Shallow, Silty, Clayey, Thin Claypan, and Shallow to Gravel range sites.

WETLAND RANGE SITE

This site is on low parts of the landscape that normally receive additional amounts of water from surface runoff or underground seepage. The soils are very wet clays to fine sandy loams. They are very poorly drained and in most areas are subject to strong seepage.

The vegetation is dominated by plants that are adapted to very wet soils, but not so wet as the soils that support marsh vegetation. Tall wetland sedges and grasses are dominant on the site and govern the general aspect throughout most of the season. Primary species in the climax plant community are slough sedge and rivergrass. Secondary species are American mannagrass, woolly sedge, reed canarygrass, prairie cordgrass, northern reedgrass, slim sedge, and Baltic rush. The common forbs are tall white aster, Rydberg's sunflower, Jerussalem artichoke, sunflower, and longrooted smartweed.

Continuous heavy grazing by cattle results in a decrease in slough sedge, woolly sedge, rivergrass, prairie cordgrass, and northern reedgrass, and an increase in fescue sedge and slim sedge. Other common increasers or invaders are mat muhly, Baltic rush, common spike sedge, and sandbar willow. Fowl bluegrass and foxtail barley often invade when heavily grazed wetlands become dry early in the growing season.

Total annual production if this site is in excellent condition is approximately 5,300 to 7,000 pounds of herbage per acre.

WET MEADOW RANGE SITE

The soils in this range site are wet clay loams to fine sandy loams. They are poorly drained soils in shallow depressions and seeped areas, chiefly on flats and in swales. Generally the soils in depressions are flooded by snowmelt in spring and are lightly flooded by heavy thundershowers during the growing season. The seeped soils generally dry out at the surface about midsummer, but have some free water within the root zone for most of the growing season. This site borders the Wetland range site in places, as a narrow band around its outer periphery.

This site is generally a lush meadow. Primary species in the climax plant community are slim sedge, woolly sedge, fescue sedge, northern reedgrass, and prairie cordgrass. Secondary species are switchgrass, mat muhly, Baltic rush, fowl bluegrass, and common spike-sedge. Forbs common to the site are wild mint, Rydberg's sunflower, tall white aster, and tall goldenrod.

A decline in range condition as a result of overuse by cattle is indicated by a decrease in slim sedge, northern reedgrass, prairie cordgrass, and switchgrass. Plants that increase under heavy grazing are fescue sedge, common spike-sedge, mat muhly, fowl bluegrass, and Baltic rush.

Total annual production if this site is in excellent condition is approximately 4,300 to 5,500 pounds of herbage per acre.

SUBIRRIGATED RANGE SITE

The soils in this range site range from clay loam to loamy fine sand. They are on flats and in imperfectly drained swales and shallow depressions. Flooding occurs in places for brief periods, generally during spring runoff. The underground water level is sufficient to keep the root zone moist for most of the growing season.

The climax plant community is dominated by tall grasses and an understory of sedges and forbs. Woody plants occur in places as a minor part of the plant community. Big bluestem and switchgrass are the primary species. Secondary species are northern reedgrass, indiangrass, little bluestem, slim sedge, fescue sedge, prairie cordgrass, and Kentucky bluegrass. Forbs common to the site are tall white aster, tall goldenrod, rush aster, and tall gayfeather.

Under continued heavy grazing by cattle, big bluestem, switchgrass, little bluestem, and yellow indiangrass decrease in the plant community. Such plants as slim sedge, fescue sedge, mat muhly, Baltic rush, and common spike-sedge increase as range condition declines. A number of forbs, such as buttercup, cinquefoil, and vervain, invade if the range is in poor condition.

Total annual production if this site is in excellent condition is approximately 3,700 to 5,000 pounds of herbage per acre.

OVERFLOW RANGE SITE

This site is in shallow swales, at the lower ends of long hillsides, and on low terraces or bottom lands along streams. It regularly receives some flooding in the form of runoff from higher lying areas or from stream overflow on the low terraces. The soils are silty clays to loams.

Tall and mid grasses are dominant on the site if it is in excellent condition. Primary species in the climax plant community are big bluestem, green needlegrass, and porcupinegrass. Secondary species are needle-and-thread, bearded wheatgrass, prairie cordgrass, Canada wildrye, and prairie dropseed. Common forbs are tall goldenrod, heath aster, tall white aster, and several species of sunflowers. Several such woody species as western snowberry, juneberry, smooth sumac, and common chokecherry are common. Sites along the Sheyenne River are typically dominated by trees and shrubs. Common trees are boxelder, green ash, cottonwood, and American elm.

Under continuous heavy grazing by cattle, the site deteriorates to upland sedges, short grasses, and unpalatable forbs. Big bluestem and green needlegrass decrease, and such plants as Penn sedge, fescue sedge, mat

muhly, and Kentucky bluegrass increase as range condition declines.

Total annual production if this site is in excellent condition is approximately 3,000 to 4,000 pounds of herbage per acre.

SANDY RANGE SITE

The soils in this range site are nearly level to undulating, well-drained to somewhat poorly drained loams and fine sandy loams. They are more fertile than soils in the Sands range site.

Primary species in the climax plant community are prairie sandreed and needle-and-thread. Secondary grasses and grasslike plants are sun sedge, Penn sedge, blue grama, native wheatgrass, little bluestem, porcupinegrass, and Kentucky bluegrass. A wide variety of forbs make up approximately 15 percent, by weight, of the total annual production. Common forbs are heath aster, white sagewort, soft goldenrod, western ragweed, and western yarrow. Woody plants, including leadplant amorpha, prairie rose, and western snowberry, are present in minor amounts.

Under continuous heavy grazing by cattle, range condition and productivity decline as needle-and-thread and prairie sandreed decrease, along with a marked increased in sun sedge, blue grama, western yarrow, western ragweed, and several species of sagewort and goldenrod.

Total annual production if this site is in excellent condition is approximately 2,400 to 3,300 pounds of herbage per acre.

SANDS RANGE SITE

The soils in this range site are deep, well drained and moderately well drained loamy fine sands and loamy sands. They are generally on flat to undulating plains, but are smooth to hilly in places. They take in water rapidly, and moisture penetration is deep, which favors deep rooting of plants.

Primary species in the climax plant community are sand bluestem, prairie sandreed, prairie junegrass, and needle-and-thread. Secondary plants are Penn sedge, sun sedge, blue grama, little bluestem, and porcupinegrass. This site generally supports a variety of such forbs as purple prairieclover, prairie spiderwort, American vetch, sunflower species, shell-leaf penstemon, and dotted gayfeather. Woody plants commonly make up 10 percent of the total annual production of herbage by weight. Common woody plants are leadplant amorpha, western snowberry, and prairie rose.

Under continuous heavy grazing by cattle, sand bluestem, prairie sandreed, and needle-and-thread decrease in the plant community. Plants that increase under heavy grazing are sun sedge, sand dropseed, blue grama, several species of goldenrod, white sagewort, and a variety of annual forbs.

Total annual production if this site is in excellent condition is approximately 2,500 to 3,400 pounds of herbage per acre.

THIN SANDS RANGE SITE

The soils in this range site are deep, well-drained sandy soils that have a thin layer of loamy fine sand over a layer in which organic matter has accumulated that is only about 6 inches thick. These soils lack the stability of older sandy soils and are more susceptible to erosion. Most areas are hilly, but in some the slope is only about 3 percent. Blowouts of 1 to several acres have recently been active, but are now stabilized.

This site supports a variety of mid and tall grasses, sedges, forbs, and woody plants. The plant cover is more sparse than that on the more fertile sandy soils.

Primary plants in the climax plant community are sand bluestem, prairie sandreed, and needle-and-thread. Secondary species are sand dropseed, Canada wildrye, blue grama, sun sedge, Penn sedge, and little bluestem. Common forbs are prairie spiderwort, silky prairieclover, lemon scurfpea, and white sagewort. Common woody plants are western snowberry, Woods rose, leadplant, and chokecherry. Scattered bur oak trees occur on parts of this site, and small clumps of aspen in favored places are common.

Under continuous heavy grazing by cattle, prairie sandreed, needle-and-thread, and sand bluestem decrease. Plants that increase as range condition declines are sun sedge, blue grama, sand dropseed and Kentucky bluegrass, field sagewort, and western ragweed.

Total annual production if this site is in excellent condition is approximately 1,800 to 2,400 pounds of herbage per acre.

THIN UPLAND RANGE SITE

This site is mainly hilly to steep terrain. The soils are deep and well drained or somewhat excessively drained and medium textured. They have a thin surface layer and solum and a high concentration of lime close to the surface. Permeability is moderate, and runoff is moderate to rapid.

The primary species in the climax plant community are little bluestem, side-oats grama, and needle-and-thread. Secondary species are plains muhly, native wheatgrasses, threadleaf sedge, Penn sedge, porcupinegrass, green needlegrass, and prairie dropseed. Common forbs are stiff sunflower, purple prairieclover, American vetch, dotted gayfeather, and purple coneflower. The proportion of woody plants is small.

Range deterioration from heavy continuous grazing by cattle results in a decrease in little bluestem, side-oats grama, and needle-and-thread. Plants that increase under heavy grazing are threadleaf sedge, blue grama, stiff sunflower, broom snakeweed, and sageworts. Western snowberry, which is natural to the site on lower parts of slopes or on northern exposures, increases significantly as range condition declines.

Total annual production if this site is in excellent condition is approximately 2,000 to 2,800 pounds of herbage per acre.

VERY SHALLOW RANGE SITE

This site is mainly rolling to hilly. The soils are of medium texture to a depth of 10 inches or less and are underlain by a layer of gravel. Available water capacity is low. The layer of gravel severely affects downward root growth.

The plant cover on this site consists of drought-tolerant species. Primary species in the climax plant

community are needle-and-thread, blue grama, and western wheatgrass. Secondary species are threadleaf sedge, Penn sedge, plains muhly, prairie junegrass, prairie dropseed, and red three-awn. Common forbs are dotted gayfeather, skeletonweed, white penstemon, and sageworts. Woody plants are present in minor amounts.

Under continuous heavy grazing by cattle, needle-and-thread and western wheatgrass decrease. Plants that increase with a decline in range condition are blue grama, threadleaf sedge, needleleaf sedge, red three-awn, and fringed sage.

Total annual production if this site is in excellent condition is approximately 850 to 1,200 pounds of herbage per acre.

SILTY RANGE SITE

This site is mainly in an area of smooth to undulating terrain, most of which is under cultivation. The part used as range is mainly the relatively smooth terrain in the Sheyenne National Grassland and the steeper, hilly areas in other parts of the survey area. The soils are deep, well drained and moderately well drained loams and silt loams. Intake rate is moderate if the range is in excellent condition. Soil fertility is generally high, and stored soil water is readily released to plants.

If this site is in excellent condition, the plant cover is mainly mid and tall grasses and forbs and an understory of sedges and short grasses. The primary species are western wheatgrass, needle-and-thread, green needlegrass, and bearded wheatgrass. Secondary species are porcupinegrass, Penn sedge, blue grama, and Kentucky bluegrass. Common forbs are heath aster, western yarrow, Missouri goldenrod, woolly goldenrod, white sagewort, and scarlet globemallow. Common woody plants, such as prairie rose, western snowberry, and fringed sage, are present in minor amounts.

A decline in range condition as a result of continuous heavy grazing by cattle is indicated by a decrease in green needlegrass, needle-and-thread, and bearded wheatgrass. Plants that increase under heavy grazing are Kentucky bluegrass, blue grama, western wheatgrass, needleleaf sedge, fringed sage, and several unpalatable forbs.

Total annual production if this site is in excellent condition is approximately 2,350 to 3,150 pounds of herbage per acre.

CLAYEY RANGE SITE

The soils in this range site are nearly level, deep, fine textured, and well drained to poorly drained. Available water capacity is high, but the intake rate is moderate to slow, depending on slope and plant cover. Most of the acreage is under cultivation, and only scattered grassy tracts remain.

The vegetation typical of the potential plant community is mid grasses, upland sedges, mid and tall forbs, and minor amounts of woody plants. Primary plant species are western wheatgrass, green needlegrass, blue grama, and Kentucky bluegrass. Secondary species are porcupinegrass, needle-and-thread, Penn sedge, wild parsley, crested beardtongue, and fringed sage.

Under continuous heavy grazing by cattle, green needlegrass and needle-and-thread decrease, and such plants as blue grama, Penn sedge, and fringed sage increase and become dominant. Several forbs also increase significantly under excessive grazing.

Total annual production if this site is in excellent condition is approximately 2,100 to 3,000 pounds of herbage per acre.

THIN CLAYPAN RANGE SITE

In this range site are alkali soils on lowlands and smooth flats. In some areas soils are also affected by soluble salts at the surface. The soils have a thin, moderately fine to moderately coarse textured surface layer underlain by a hard clay subsoil. The subsoil is high in sodium, which causes a dispersed soil condition that restricts root penetration.

If this site is in excellent condition, the dominant plants are western wheatgrass and blue grama. Secondary plants are inland saltgrass, needleleaf sedge, Nuttall alkaligrass, prairie junegrass, green needlegrass, and fringed sage. Where salts are more concentrated, inland saltgrass and Nuttall alkaligrass are site dominants. Only minor amounts of woody plants are common to this site.

A decline in range condition as a result of continuous heavy grazing by cattle is indicated by a decrease in western wheatgrass, green needlegrass, and prairie junegrass. Plants that increase under heavy grazing are blue grama, inland saltgrass, and alkali muhly. Tumblegrass and annual saltbushes are common invaders.

Total annual production if this site is in high range condition is approximately 1,250 to 1,950 pounds of herbage per acre.

SHALLOW TO GRAVEL RANGE SITE

This site is in relatively smooth glacial outwash areas and on terraces and beaches. The soils are moderately fine textured to moderately coarse textured and well drained. They are underlain by coarse sand or gravel at a depth of 10 to 20 inches. The layer of gravel has a low water-holding capacity and for this reason restricts roots. The soils, therefore, are droughty when compared with other soils, even though water intake is rapid to moderate.

The vegetation on this site is mainly mid grasses, short grasses, a considerable proportion of drought-tolerant forbs, and minor quantities of woody plants. The principal plants in the climax plant community are needle-and-thread, native wheatgrasses, and blue grama. Secondary plants are sun sedge, Penn sedge, green needlegrass, prairie junegrass, and porcupinegrass. Common forbs are dotted gayfeather, scarlet globemallow, and skeletonweed. Shrubs and half shrubs are fringed sage, pricklypear cactus, and prairie rose.

Under continuous heavy grazing by cattle, needle-and-thread, western wheatgrass, and green needlegrass decrease in the plant community, and such plants as sun sedge, Penn sedge, blue grama, fringed sage, and red three-awn increase and become dominant.

Total annual production if this site is in excellent condition is approximately 1,600 to 2,100 pounds of herbage per acre.

Figure 22.—**Single-row field windbreak on Hecla-Hamar loamy fine sands. These soils are highly susceptible to blowing.**

Woodland and Windbreaks[5]

Approximately 14,000 acres in the survey area is native woodland. Most of the trees and shrubs are on the Cashel, Fairdale, LaPrairie, and Wahpeton soils adjacent to the Red River, the Sheyenne River, the Wild Rice River, and Antelope Creek. They are also in swales on the Svea and Aastad soils and in the Sandhills on the Serden, Maddock, and Hecla soils.

The most common species are boxelder, American elm, green ash, eastern cottonwood, basswood, quaking aspen, bur oak, chokecherry, juneberry, wild plum, red-osier dogwood, and shrub willows. Russian-olive, an introduced species, is becoming common on wetland areas, particularly in the western part of the survey area.

The early settlers used the trees for lumber, fence posts, and fuel. Today, trees and shrubs are used mainly for livestock protection, wildlife habitat, recreation, erosion control, and watershed protection.

Since settlement, windbreaks have been planted for protection of farmsteads and livestock. A need for such plantings still exists around many of the farmsteads. There is a growing interest in the planting of field windbreaks to control erosion in cultivated areas where the soils are susceptible to blowing (fig. 22). Thousands of acres of soils within the survey area are still in need of some form of wind protection.

Windbreaks return many economic and environmental benefits to the landowner. They distribute and hold snow and prevent the snow from drifting around the farmstead; they protect the home and livestock from cold, wintery winds, which reduces fuel and feed costs; they protect field crops, gardens, and orchards from strong damaging winds; they reduce evaporation of moisture; they provide a suitable habitat for many kinds of birds and other wildlife; they help control soil erosion; and they enhance the beauty of the rural home and its surroundings.

Items to be considered before a windbreak is planted are the purpose of planting, the suitability of the soils, the suitability of selected trees and shrubs, and the location. Improperly designed windbreaks can cause many problems.

Establishment of a windbreak and continued growth of the trees depend upon careful selection, suitable preparation, and adequate maintenance of the site. Grass and weeds have to be eliminated before the trees are

[5] By David L. Hintz, forester, Soil Conservation Service.

TABLE 3.—*Height and vigor, by windbreak*

[Height measurements and vigor ratings are for trees at 20

Windbreak group	Eastern redcedar and Rocky Mountain juniper		Ponderosa pine		Black Hills spruce and Colorado blue spruce		Caragana		Chokeberry		Honeysuckle	
	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
		Feet		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*
1	Good	11–13	Good	18–22	Good	16–20	Good	9–11	Good	11–14	Good	8–10
[1] 2	Good	11–13	Good	20–22	Good	15–18	Fair	7–9	Good	9–11	Good	7–9
3	Good	12–15	Good	18–22	Good	15–18	Good	8–10	Good	10–12	Good	8–10
4	Good	10–12	Good	17–19	Fair	15–18	Good	6–8	Good	8–10	Good	6–8
5	Good	9–11	Good	15–20	Poor	—	Good	8–10	Good	8–10	Good	7–9
6	Fair	8–10	Fair	14–18	Poor	—	Fair	7–9	Fair	7–9	Fair	6–8
8	Fair	7–9	Fair	11–14	Poor	—	Fair	5–7	Poor	—	Fair	5–7

[1] Height measurements and vigor ratings are for drained areas.

planted, and the regrowth of the ground cover should be controlled for the entire life of the windbreak. Some replanting is likely to be needed during the first and second years.

Windbreak suitability groups

The soils of North Dakota have been grouped into 10 windbreak suitability groups. All but windbreak group 7 are in this survey area. If well managed, adapted trees and shrubs respond in about the same way on all the soils in a group.

Several factors are considered in grouping soils into windbreak suitability groups, but the dominant and most critical factor is the amount and seasonal availability of soil moisture. Hence, most groups contain soils that range widely in slope and texture of the surface layer. These two soil characteristics largely determine the degree of hazard of water erosion and soil blowing.

Coarse-textured soils are highly susceptible to blowing. Moderately coarse textured and fine textured soils are susceptible, medium-textured soils moderately to slightly susceptible, and moderately fine textured soils only slightly susceptible.

The hazard of water erosion is none to slight if the slope is 1 to 3 percent. It is moderate if the slope is 3 to 6 percent, severe if 6 to 9 percent, severe to very severe if 9 to 12 percent, and very severe if 12 percent or more.

Water conserving measures are needed for satisfactory tree growth on all soils that have slopes of more than 6 percent. Special site preparation, planting, and cultivation are needed to successfully establish and maintain plantings on all soils subject to blowing or water erosion. The water table is below the reach of tree roots in all soils in groups 3 through 9 and in some soils in group 10. The soils in group 10 are very wet during at least part of the year. A few have additional limitations critical for growing trees and shrubs.

Marsh is not assigned to a windbreak group. It is so variable in soil characteristics that determining suitability is not feasible. It is suited to spot plantings for wildlife, recreational, and beautification purposes in selected locations.

Table 3 lists most of the trees and shrubs used in windbreak plantings. It shows the actual or estimated average height, growth, and the vigor of the various species at 20 years of age. Vigor refers to the density of foliage, the freedom from damage from insects or disease, and the general appearance of the tree. All height measurements and vigor ratings in table 3 are based on well-managed plantings.

A rating of *good* indicates the following conditions: Leaves or needles normal in color and growth; only a small amount of deadwood (tops, branches, twigs) within the live crown; little or no evidence of disease, insect, or climatic damage; and little or no evidence of stagnation or suppression.

A rating of *fair* indicates one or more of the following conditions: Leaves or needles obviously abnormal in color and growth; substantial amounts of deadwood (tops, branches, and twigs) within the live crown; evidence of moderate disease, insect, or climatic damage; definite suppression or stagnation; and current year's growth obviously less than normal.

A rating of *poor* indicates one or more of the following conditions: Leaves or needles very abnormal in color and growth; very large amounts of deadwood (tops, branches, and twigs) within the live crown; evidence of extensive disease, insect, or climatic damage; severe stagnation, suppression, or decadence; and current year's growth essentially negligible. Plants that have this rating are not recommended for farmstead, feedlot, or field windbreaks. They may be satisfactory for some wildlife and beautification plantings.

The windbreak suitability groups in the survey area are described on the following pages.

WINDBREAK SUITABILITY GROUP 1

In this group are deep, nearly level to undulating soils that range in texture from loamy sand to clay. They contain moisture favorable to the survival and growth of trees and shrubs. Some of these soils have a

group, of selected trees and shrubs

years of age. Dashes indicate data not available]

Wild plum		American elm		Cottonwood		Green ash		Russian-olive		Siberian elm	
Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height	Vigor	Height
	Feet		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*
Good	7-9	Good	22-27	Good	40-48	Good	21-26	Fair	15-19	Good	28-35
Good	6-7	Good	20-25	Good	38-45	Good	21-26	Fair	15-19	Fair	28-32
Good	8-10	Good	20-25	Poor	—	Good	20-25	Fair	14-18	Good	26-32
Good	7-9	Fair	15-19	Poor	—	Good	16-20	Fair	12-15	Good	22-26
Good	7-9	Fair	15-19	Poor	—	Fair	15-20	Fair	11-14	Good	20-25
Fair	6-8	Fair	14-18	Poor	—	Fair	14-18	Fair	11-14	Fair	17-22
Poor	—	Poor	—	Poor	—	Fair	14-18	Fair	11-14	Fair	14-18

water table within the reach of tree roots, and others receive additional moisture in the form of runoff from higher surrounding soils.

These soils are well suited to all types of windbreaks and other woody plantings. Except on soils subject to moderate to severe blowing, there are no serious limitations to planting of trees and shrubs.

WINDBREAK SUITABILITY GROUP 2

In this group are deep, nearly level soils that range in texture from loamy fine sand to clay. They are poorly drained and very poorly drained and are occasionally to frequently ponded. The water table is within 1 to 3 feet of the surface during most of the growing season.

Excess water has to be removed for satisfactory survival of trees and shrubs. If excess water can be removed, these soils are well suited to all types of windbreaks and woody plantings. Some of the sandier soils in this group are susceptible to soil blowing if the surface is left bare and dry. Water erosion is no problem. The main limitation to the survival and growth of trees and shrubs is excess soil wetness.

WINDBREAK SUITABILITY GROUP 3

In this group are nearly level to hilly, well-drained soils that range from loam to silty clay loam. One soil is moderately deep, and the rest are deep. The water table is below the root zone of trees and shrubs, and in most areas runoff is medium to rapid.

The soils in this group are well suited to all types of windbreaks and other woody plantings. The main considerations are conserving water and controlling runoff and water erosion.

WINDBREAK SUITABILITY GROUP 4

In this group are deep, nearly level, undulating, and rolling soils. The surface layer ranges in texture from fine sandy loam to silty clay, and the subsoil is heavy clay loam, silty clay loam, silty clay, or clay. Sodic layers occur in the lower part of the subsoil in some areas.

The soils in this group are suited to windbreaks and woody plantings if proper trees and shrubs are selected. The number of trees and shrubs that grow well on these soils is limited. One soil in this group is highly susceptible to water erosion. Otherwise, the main limitation to the growth of trees and shrubs is a clayey subsoil.

WINDBREAK SUITABILITY GROUP 5

In this group are deep, nearly level to rolling, well-drained soils. The surface layer ranges from loamy sand to fine sandy loam. These soils absorb water readily, but they have a low or moderate available water capacity. Some precipitation is lost as runoff. The water table is below the reach of tree roots.

These soils are suited to windbreaks and other woody plantings if proper tree and shrub species are selected. The number of tree and shrub species that grow well on these soils is limited. The hazard of soil blowing is severe on all these soils. The main limitation to tree and shrub growth is the low to moderate available water capacity.

WINDBREAK SUITABILITY GROUP 6

In this group are nearly level to gently sloping soils that are less than 25 inches deep over coarse sand and gravel. The surface layer is loam or fine sandy loam.

These soils absorb water readily, but the available water capacity is low because of the underlying sand and gravel. The water table is below the reach of tree roots. No known species of trees and shrubs grow well on these soils.

The soils in this group are poorly suited to windbreaks and other woody plantings. Some woody plantings, however, can be established if optimum survival, growth, and vigor are not required or expected. The hazard of soil blowing is moderate to severe. The main limitations to tree and shrub growth and survival are the low available water capacity and the shallow root zone.

WINDBREAK SUITABILITY GROUP 8

In this group are deep, undulating to steep soils that are well drained or somewhat excessively drained. Run-

off is medium to rapid, and the hazard of water erosion is moderate to very severe. These soils have a loam or silt loam surface layer 2 to 12 inches thick. The available water capacity is high, but a large part of the precipitation is lost as runoff.

Trees and shrubs do not grow well on these soils. Farmstead and feedlot windbreaks and other types of woody plantings can be established if tree and shrub species are properly selected. Optimum survival, growth, and vigor, however, should not be required or expected. These soils are poorly suited to field windbreaks. The main limitation to the survival and growth of trees and shrubs is rapid runoff, which restricts water intake and creates a severe hazard of water erosion.

WINDBREAK SUITABILITY GROUP 9

In this group are level soils that are deep and somewhat poorly drained or poorly drained. They have a loam to silty clay surface layer that is shallow or very shallow over a sodic claypan subsoil. The available water capacity is low to moderate because the level of salts is high in the subsoil and underlying material. No known species of trees and shrubs grow well on these soils.

The soils in this group are unsuited to windbreaks and other woody plantings. The critical limitations for tree and shrub survival and growth are the shallow root zone, the low to moderate available water capacity, and the high level of sodium salts near the soil surface.

WINDBREAK SUITABILITY GROUP 10

In this group are moderately saline, shallow, and sandy soils and Peat, Stabilized dune land, Strongly saline land, and Wet alluvial land. Two of the soils are undulating to hilly. The rest are nearly level.

Soils in this group range widely in depth, drainage, and texture. They are either too wet, steep, and saline or too low in available water for trees and shrubs to grow. No known species of tree or shrub grows well on these soils.

Windbreaks and other woody plantings are not suited. Excess wetness, salinity, low available water capacity, and steep slopes prevent satisfactory growth and survival of trees and shrubs.

Wildlife and Recreation[6]

The paragraphs that follow describe the wildlife and recreation in the survey area and suggest how the soils can be used as wildlife habitat and for recreational development.

Wildlife

Wildlife and fisheries are significant in providing outdoor activities for the people in the survey area. They also contribute to the economy.

The numbers of fish and wildlife have been reduced substantially since the area was first settled, but the species are still somewhat similar. Habitat is available for many species.

[6] By ERLING B. PODOLL, biologist, Soil Conservation Service.

Such birds as wild geese and sandhill cranes no longer nest in the county. Extirpated mammals, such as moose, antelope, elk, and bear, have not been replaced by a wild species. Token populations of the greater prairie chicken, sharp-tailed grouse, and pileated woodpecker still remain.

The most important present-day game species are ducks, geese (not as breeders, but as hunting populations), pheasant, gray (Hungarian) partridge, and white-tailed deer. Mourning dove, cottontail rabbit, and fox squirrel tend to be under-utilized game species. Red fox and jackrabbit are important furbearers and provide an important source of game for winter outdoor recreation.

Pheasant populations have been low throughout the State during recent years. The survey area provides only about 6 percent of the statewide harvest. The season on sharp-tailed grouse has been closed during most recent years. The area provides only a trace of the statewide harvest of gray partridge, more than 7 percent of the statewide harvest of cottontails, and 15 percent of the statewide harvest of tree squirrel. A few hundred white-tailed deer are harvested each year.

Public fishing in the survey area is provided by the Red River of the North, the Bois de Sioux, the Sheyenne, and the Wild Rice Rivers and Lake Elsie. Fishing in the Wild Rice River is seasonal and depends on the amount of runoff.

The potential is very small for fish dams in the survey area. There is some potential for excavated fish ponds. The most commonly sought fish are perch, bullhead, northern pike, walleye, and catfish.

In table 4 the soils in the survey area are rated for three general kinds of wildlife. Ratings are based on the capacity of the soil to produce the various habitat elements needed for the specified kind of wildlife.

The wildlife considered as *rangeland wildlife* are white-tailed deer, sharp-tailed grouse, horned lark, jackrabbit, and similar species that depend on range plants. *Wetland wildlife,* such as duck, heron, shorebirds, mink, muskrat, geese, and coot, normally depend on natural wetlands and their environments. *Openland wildlife,* such as gray partridge, pheasant, cottontail rabbit, red fox, gold finch, and ground squirrel, tolerate or depend on disturbed soil or annual plants.

Woodland wildlife is not considered in table 4. The small acreages of natural woodland, locally, small wooded tracts, provide habitat for thrushes, vireos, and tree squirrels, which require only small woodland niches.

Habitat elements for openland wildlife are grain and seed crops, domestic grasses and legumes, and wild herbaceous plants and shrubs.

Habitat elements for rangeland wildlife are wild herbaceous plants and shrubs.

Habitat elements for wetland wildlife are wetland plant sites and shallow water areas.

The potential of each mapping unit for providing the needed habitat is expressed as *good, fair, poor,* or *very poor.*

Most wildlife habitat is created, improved, or maintained by managing existing vegetation, planting suitable vegetation, inducing natural establishment of de-

TABLE 4.—*Suitability of soils for kinds of wildlife*

Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Aastad-Forman loams:			
Aastad soil	Good	Good	Poor.
Forman soil	Good	Fair	Very poor.
Aberdeen fine sandy loam	Good	Fair	Fair.
Aberdeen silt loam	Fair	Fair	Fair.
Aberdeen-Galchutt silty clay loams:			
Aberdeen soil	Fair	Fair	Fair.
Galchutt soil	Good	Fair	Fair.
Aberdeen-Ryan silty clay loams:			
Aberdeen soil	Fair	Fair	Fair.
Ryan soil	Poor	Very poor	Fair.
Antler silty clay loam	Good	Fair	Fair.
Antler-Tonka silty clay loams:			
Antler soil	Good	Fair	Fair.
Tonka soil	Good	Fair	Good.
Arveson-Fossum fine sandy loams	Fair	Fair	Good.
Arveson and Fossum loams	Good	Fair	Good.
Arveson and Fossum loams, very wet	Poor	Poor	Good.
Arvilla fine sandy loam	Fair	Poor	Very poor.
Barnes-Buse loams, hilly	Good	Fair	Very poor.
Barnes-Buse loams, hilly, eroded	Good	Fair	Very poor.
Barnes-Buse-Langhei loams, hilly	Fair	Fair	Very poor.
Barnes-Svea loams, undulating:			
Barnes soil	Good	Fair	Very poor.
Svea soil	Good	Good	Very poor.
Bearden silty clay loam	Good	Fair	Fair.
Bearden and Glyndon silt loams, moderately deep over clay	Good	Fair	Fair.
Borup loam	Fair	Fair	Good.
Borup silt loam, very wet	Poor	Poor	Good.
Cashel silty clay	Good	Fair	Fair.
Colvin silty clay loam	Fair	Fair	Good.
Dickey-Towner fine sandy loams, undulating	Good	Fair	Very poor.
Doran clay loam	Good	Fair	Fair.
Doran-Perella clay loams:			
Doran soil	Good	Fair	Fair.
Perella soil	Good	Fair	Good.
Doran-Tonka silty clay loams:			
Doran soil	Good	Fair	Fair.
Tonka soil	Good	Fair	Good.
Dovray silty clay	Poor	Poor	Good.
Eckman-Zell silt loams, rolling	Good	Fair	Very poor.
Egeland and Maddock fine sandy loams, undulating	Good	Fair	Very poor.
Embden-Tiffany fine sandy loams:			
Embden soil	Good	Fair	Poor.
Tiffany soil	Good	Fair	Good.
Embden-Tiffany loams:			
Embden soil	Good	Fair	Poor.
Tiffany soil	Good	Fair	Good.
Exline and Ryan soils	Poor	Very poor	Fair.
Fairdale silt loam	Good	Fair	Poor.
Fairdale silt loam, channeled	Good	Fair	Poor.
Fairdale silty clay loam	Good	Fair	Poor.
Fargo silty clay loam	Fair	Poor	Fair.
Fargo silty clay	Fair	Poor	Fair.
Fargo silty clay, depressional	Fair	Poor	Good.
Fargo silty clay, gently sloping	Fair	Poor	Very poor.
Fargo silty clay, till substratum	Fair	Poor	Fair.
Fargo-Enloe silty clay loams:			
Fargo soil	Fair	Poor	Fair.
Enloe soil	Fair	Poor	Good.
Fargo-Enloe complex, till substratum:			
Fargo soil	Fair	Poor	Fair.
Enloe soil	Fair	Poor	Good.
Fargo-Hegne silty clays	Fair	Poor	Fair.
Fargo-Hegne silty clays, till substratum	Fair	Poor	Fair.
Fargo-Ryan silty clay loams:			
Fargo soil	Fair	Poor	Fair.
Ryan soil	Poor	Very poor	Fair.
Fargo-Ryan silty clays:			
Fargo soil	Fair	Poor	Fair.
Ryan soil	Poor	Very poor	Fair.

TABLE 4.—*Suitability of soils for kinds of wildlife*—Continued

Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Fordville-Renshaw loams:			
Fordville soil	Fair	Fair	Very poor.
Renshaw soil	Fair	Poor	Very poor.
Forman-Aastad loams, undulating:			
Forman soil	Good	Fair	Very poor.
Aastad soil	Good	Good	Very poor.
Forman-Aastad loams, undulating, eroded:			
Forman soil	Good	Fair	Very poor.
Aastad soil	Good	Good	Very poor.
Forman-Buse loams, rolling	Good	Fair	Very poor.
Forman-Buse loams, rolling, eroded	Good	Fair	Very poor.
Forman-Peever clay loams, undulating	Good	Fair	Very poor.
Fossum fine sandy loam	Fair	Fair	Good.
Galchutt silt loam	Good	Fair	Fair.
Galchutt-Enloe-Fargo complex:			
Galchutt soil	Good	Fair	Fair.
Enloe soil	Fair	Poor	Good.
Fargo soil	Fair	Poor	Fair.
Galchutt-Overly silt loams:			
Galchutt soil	Good	Fair	Fair.
Overly soil	Good	Fair	Poor.
Gardena silt loam	Good	Fair	Poor.
Gardena-Eckman silt loams, undulating	Good	Fair	Very poor.
Gardena and Embden loams	Good	Fair	Poor.
Gilby silt loam	Good	Fair	Fair.
Gilby silt loam, moderately saline	Fair	Poor	Fair.
Gilby and Hamerly loams	Good	Fair	Fair.
Glyndon silt loam	Good	Fair	Fair.
Glyndon-Tiffany very fine sandy loams:			
Glyndon soil	Good	Fair	Fair.
Tiffany soil	Good	Fair	Good.
Glyndon-Tiffany loams, moderately deep over clay	Good	Fair	Fair.
Glyndon and Wyndmere loams	Good	Fair	Fair.
Grano clay	Poor	Poor	Good.
Hamar fine sandy loam	Fair	Fair	Fair.
Hamar fine sandy loam, moderately deep over clay	Fair	Fair	Good.
Hamar loamy fine sand	Fair	Fair	Fair.
Hamar loamy fine sand, moderately deep over clay	Fair	Fair	Good.
Hamar-Ulen fine sandy loams:			
Hamar soil	Fair	Fair	Fair.
Ulen soil	Good	Fair	Poor.
Hamar-Ulen loamy fine sands:			
Hamar soil	Fair	Fair	Fair.
Ulen soil	Good	Fair	Poor.
Hamerly loam	Good	Fair	Fair.
Hecla loamy fine sand, loamy substratum	Good	Fair	Poor.
Hecla-Hamar-Arveson complex:			
Hecla soil	Good	Fair	Very poor.
Hamar soil	Fair	Fair	Fair.
Arveson soil	Fair	Fair	Good.
Hecla-Hamar fine sandy loams:			
Hecla soil	Good	Fair	Very poor.
Hamar soil	Good	Fair	Fair.
Hecla-Hamar loamy fine sands:			
Hecla soil	Good	Fair	Very poor.
Hamar soil	Fair	Fair	Fair.
Hecla-Hamar loamy fine sands, severely eroded:			
Hecla soil	Fair	Fair	Very poor.
Hamar soil	Fair	Fair	Fair.
Hecla-Maddock loamy sands	Good	Fair	Very poor.
Hecla-Maddock sandy loams	Good	Fair	Very poor.
Kratka fine sandy loam	Fair	Fair	Good.
LaDelle silty clay loam	Good	Good	Poor.
LaDelle and Wahpeton soils, channeled:			
LaDelle soil	Fair	Good	Poor.
Wahpeton soil	Fair	Fair	Poor.
Lamoure silty clay loam	Good	Fair	Good.
LaPrairie silt loam	Good	Good	Poor.
Maddock loamy fine sand, rolling	Fair	Fair	Very poor.
Maddock-Hecla loamy fine sands, undulating	Good	Fair	Very poor.
Maddock-Hecla-Hamar loamy fine sands, undulating:			
Maddock soil	Good	Fair	Very poor.
Hecla soil	Good	Fair	Very poor.
Hamar soil	Fair	Fair	Fair.

TABLE 4.—*Suitability of soils for kinds of wildlife*—Continued

Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Marsh	Very poor	Very poor	Good.
Nutley silty clay, rolling	Fair	Poor	Very poor.
Overly silty clay loam	Good	Fair	Poor.
Overly-Beotia silty clay loams, undulating	Good	Fair	Very poor.
Overly-Bearden silty clay loams, moderately saline:			
Overly soil	Fair	Poor	Poor.
Bearden soil	Fair	Poor	Fair.
Overly-Bearden silt loams, moderately saline:			
Overly soil	Fair	Poor	Poor.
Bearden soil	Fair	Poor	Fair.
Parnell silty clay loam	Poor	Poor	Good.
Parnell and Tonka silty clay loams:			
Parnell soil	Poor	Poor	Good.
Tonka soil	Good	Fair	Good.
Peat	Poor	Poor	Good.
Peever-Forman clay loams	Good	Fair	Very poor.
Perella loam, moderately deep over clay	Good	Fair	Good.
Perella silty clay loam, moderately deep over clay	Good	Fair	Good.
Roliss clay loam	Poor	Poor	Good.
Ryan-Fargo complex:			
Ryan soil	Poor	Very poor	Fair.
Fargo soil	Fair	Poor	Fair.
Serden loamy fine sand	Poor	Fair	Very poor.
Serden-Stabilized dune land complex	Poor	Fair	Very poor.
Sioux-Renshaw complex, undulating:			
Sioux soil	Poor	Poor	Very poor.
Renshaw soil	Fair	Poor	Very poor.
Sioux-Renshaw complex, hilly	Poor	Poor	Very poor.
Stirum-Arveson loams:			
Stirum soil	Poor	Poor	Good.
Arveson soil	Good	Fair	Good.
Strongly saline land	Poor	Very poor	Fair.
Svea loam	Good	Good	Poor.
Svea-Buse loams, undulating:			
Svea soil	Good	Good	Very poor.
Buse soil	Good	Fair	Very poor.
Svea-Buse loams, rolling:			
Svea soil	Good	Good	Very poor.
Buse soil	Good	Fair	Very poor.
Svea-Gardena loams:			
Svea soil	Good	Good	Poor.
Gardena soil	Good	Fair	Poor.
Swenoda-Wyndmere fine sandy loams:			
Swenoda soil	Good	Fair	Poor.
Wyndmere soil	Good	Fair	Fair.
Tiffany fine sandy loam	Fair	Fair	Good.
Tiffany loam	Good	Fair	Good.
Tiffany loam, moderately deep over clay	Good	Fair	Good.
Tonka silt loam	Good	Fair	Good.
Towner loamy fine sand	Good	Fair	Poor.
Towner and Swenoda fine sandy loams	Good	Fair	Poor.
Ulen fine sandy loam	Good	Fair	Poor.
Vallers clay loam	Fair	Fair	Good.
Venlo fine sandy loam	Poor	Poor	Good.
Wahpeton silty clay	Fair	Poor	Poor.
Wet alluvial land	Poor	Poor	Good.
Wyndmere fine sandy loam	Good	Fair	Fair.
Zell-Eckman silt loams, hilly	Fair	Fair	Very poor.
Zell-Eckman silt loams, steep	Fair	Fair	Very poor.

sired plants, and enhancing conditions for wildlife by earthmoving, or by a combination of the foregoing.

Present land use is not considered in table 4. Neither is the relationship of one soil to another, nor the size, shape, or extent of their occurrence considered. Also, the mobility of wildlife is disregarded. The criteria, therefore, apply only to wildlife habitat potential for each mapping unit.

The information in the table can be used as an aid in selecting sites for the general kinds of wildlife or in determining the intensity of management needed to produce satisfactory results. The information also provides a means for grouping soils for broad-scale wildlife planning or for aiding landowners in selecting the management needed for desired wildlife.

For information on suitability of soil for impound-

ments, such as fish ponds or wetland developments, see the section "Engineering Uses of the Soils."

Recreation

Municipal or town parks provide most of the recreational facilities in the survey area, for example, swimming, picnicking, and such group activities as outdoor games, skating, and other sports. No public trails or camping areas have been developed.

Public lands available for recreation consist of about 70,340 acres in the Sheyenne National Grassland, about 2,400 acres in State Game Management Areas, and about 550 acres in waterfowl production areas. These lands can be used for such activities as hiking, nature study, birdwatching, and hunting. Public access to fishing waters is very limited.

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 5 the soils of the survey area are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails.

Limitations in table 5 are expressed as *slight, mod-*

TABLE 5.—*Degree and kinds of limitations for recreational facilities*

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Aastad-Forman loams	None to slight	None to slight	None to slight	None to slight.
Aberdeen fine sandy loam	Moderate: slow permeability; somewhat poorly drained.	Moderate: slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Aberdeen silt loam	Moderate: slow permeability; somewhat poorly drained.	Moderate: slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Aberdeen-Galchutt silty clay loams	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Aberdeen-Ryan silty clay loams:				
Aberdeen soil	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Ryan soil	Severe: poorly drained; very slow permeability.	Severe: poorly drained; very slow permeability.	Severe: poorly drained.	Severe: poorly drained.
Antler silty clay loam	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Antler-Tonka silty clay loams:				
Antler soil	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained; moderately slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tonka soil	Severe: poorly drained; ponding.	Severe: poorly drained, ponding.	Severe: poorly drained, ponding.	Severe: poorly drained.
Arveson-Fossum fine sandy loams	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Arveson and Fossum loams	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Arveson and Fossum loams, very wet.	Severe: poorly drained and very poorly drained; seasonal high water table; ponding.	Severe: poorly drained and very poorly drained; seasonal high water table; ponding.	Severe: poorly drained and very poorly drained; seasonal high water table; ponding.	Severe: poorly drained and very poorly drained; seasonal high water table; ponding.
Arvilla fine sandy loam	Slight to moderate: slope.	None to slight	None to slight	None to slight.
Barnes-Buse loams, hilly	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Barnes-Buse loams, hilly, eroded	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Barnes-Buse-Langhei loams, hilly	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Barnes-Svea loams, undulating	Moderate: slope	None to slight	None to slight	None to slight.
Bearden silty clay loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Bearden and Glyndon silt loams, moderately deep over clay.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.

TABLE 5.—*Degree and kinds of limitations for recreational facilities*—Continued

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Borup loam	Severe: poorly drained; seasonal high water table; ponding.	Severe: poorly drained; seasonal high water table; ponding.	Severe: poorly drained; seasonal high water table; ponding.	Severe: poorly drained.
Borup silt loam, very wet	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.
Cashel silty clay	Severe: texture of surface layer, flooding.	Severe: texture of surface layer, flooding.	Severe: texture of surface layer.	Severe: texture of surface layer.
Colvin silty clay loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Dickey-Towner fine sandy loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Doran clay loam	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: texture of surface layer.
Doran-Perella clay loams:				
Doran soil	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: texture of surface layer.
Perella soil	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Doran-Tonka silty clay loams:				
Doran soil	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: texture of surface layer.
Tonka soil	Severe: poorly drained; ponding.	Severe: poorly drained, ponding.	Severe: poorly drained, ponding.	Severe: poorly drained.
Dovray silty clay	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; texture of surface layer.
Eckman-Zell silt loams, rolling	Severe: slope	None to slight	None to slight	None to slight.
Egeland and Maddock fine sandy loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Embden-Tiffany fine sandy loams:				
Embden soil	None to slight	None to slight	None to slight	None to slight.
Tiffany soil	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Embden-Tiffany loams:				
Embden soil	None to slight	None to slight	None to slight	None to slight.
Tiffany soil	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Exline and Ryan soils:				
Exline soil	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Ryan soil	Severe: very slow permeability; poorly drained.	Severe: very slow permeability; poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Fairdale silt loam	Moderate: flooding	Moderate: flooding	Moderate: flooding	None to slight.
Fairdale silt loam, channeled	Moderate: flooding; slope.	Moderate: flooding	Moderate: flooding	None to slight.
Fairdale silty clay loam	Moderate: flooding; texture of surface layer.	Moderate: flooding; texture of surface layer.	Moderate: flooding; texture of surface layer.	Moderate: texture of surface layer.
Fargo silty clay loam	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Fargo silty clay	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Fargo silty clay, depressional	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.

TABLE 5.—*Degree and kinds of limitations for recreational facilities*—Continued

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Fargo silty clay, gently sloping	Severe: texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.
Fargo silty clay, till substratum	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Fargo-Enloe silty clay loams:				
Fargo soil	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Enloe soil	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Fargo-Enloe complex, till substratum:				
Fargo soil	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Enloe soil	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Fargo-Hegne silty clays	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Fargo-Hegne silty clays, till substratum.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Fargo-Ryan silty clay loams:				
Fargo soil	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Ryan soil	Severe: very slow permeability; poorly drained.	Severe: very slow permeability; poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Fargo-Ryan silty clays:				
Fargo soil	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Ryan soil	Severe: very slow permeability; poorly drained; texture of surface layer.	Severe: very slow permeability; poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Fordville-Renshaw loams	Slight to moderate: slope.	None to slight	None to slight	None to slight.
Forman-Aastad loams, undulating	Moderate: slope	None to slight	None to slight	None to slight.
Forman-Aastad loams, undulating, eroded.	Moderate: slope	None to slight	None to slight	None to slight.
Forman-Buse loams, rolling	Severe: slope	None to slight	None to slight	None to slight.
Forman-Buse loams, rolling, eroded.	Severe: slope	None to slight	None to slight	None to slight.
Forman-Peever clay loams, undulating.	Moderate: slope; moderately slow and slow permeability.	Moderate: moderately slow and slow permeability; texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Fossum fine sandy loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Galchutt silt loam	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Galchutt-Enloe-Fargo complex:				
Galchutt soil	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Enloe soil	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Fargo soil	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.

TABLE 5.—*Degree and kinds of limitations for recreational facilities*—Continued

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Galchutt-Overly silt loams:				
Galchutt soil	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained; slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Overly soil	None to slight	None to slight	None to slight	None to slight.
Gardena silt loam	None to slight	None to slight	None to slight	None to slight.
Gardena-Eckman silt loams, undulating.	Moderate: slope	None to slight	None to slight	None to slight.
Gardena and Embden loams	None to slight	None to slight	None to slight	None to slight.
Gilby silt loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Gilby silt loam, moderately saline.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Gilby and Hamerly loams	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Glyndon silt loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Glyndon-Tiffany very fine sandy loams:				
Glyndon soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tiffany soil	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Glyndon-Tiffany loams, moderately deep over clay:				
Glyndon soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tiffany soil	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Glyndon and Wyndmere loams	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Grano clay	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.
Hamar fine sandy loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.
Hamar fine sandy loam, moderately deep over clay.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Hamar loamy fine sand	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Hamar loamy fine sand, moderately deep over clay.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Hamar-Ulen fine sandy loams:				
Hamar soil	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Ulen soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Hamar-Ulen loamy fine sands:				
Hamar soil	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Ulen soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Hamerly loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Hecla loamy fine sand, loamy substratum.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Hecla-Hamar-Arveson complex:				
Hecla soil	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.

TABLE 5.—*Degree and kinds of limitations for recreational facilities*—Continued

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Hamar soil	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Arveson soil	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Hecla-Hamar fine sandy loams:				
Hecla soil	None to slight	None to slight	None to slight	None to slight.
Hamar soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Hecla-Hamar loamy fine sands:				
Hecla soil	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Hamar soil	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.
Hecla-Hamar loamy fine sands, severely eroded:				
Hecla soil	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Hamar soil	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.
Hecla-Maddock loamy sands	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Hecla-Maddock sandy loams	None to slight	None to slight	None to slight	None to slight.
Kratka fine sandy loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
LaDelle silty clay loam	Moderate: flooding, texture of surface layer.	Moderate: flooding, texture of surface layer.	Moderate: flooding, texture of surface layer.	Moderate: flooding, texture of surface layer.
LaDelle and Wahpeton soils, channeled:				
LaDelle soil	Moderate: flooding; texture of surface layer; slope.	Moderate: flooding; texture of surface layer.	Moderate: flooding; texture of surface layer.	Moderate: flooding; texture of surface layer.
Wahpeton soil	Severe: texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.
Lamoure silty clay loam	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained.
LaPrairie silt loam	Moderate: flooding	Moderate: flooding	Slight to moderate: flooding.	Slight to moderate: flooding.
Maddock loamy fine sand, rolling	Severe: slope	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Maddock-Hecla loamy fine sands, undulating.	Moderate: slope; texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Maddock-Hecla-Hamar loamy fine sands, undulating.				
Maddock soil	Moderate: slope; texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Hecla soil	Moderate: slope; texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Hamar soil	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Marsh	Severe	Severe	Severe	Severe.
Nutley silty clay, rolling	Severe: slope; texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.

TABLE 5.—*Degree and kinds of limitations for recreational facilities*—Continued

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Overly silty clay loam	Moderate: texture of surface layer; moderately slow permeability.	Moderate: texture of surface layer; moderately slow permeability.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Overly-Beotia silty clay loams, undulating.	Moderate: texture of surface layer; slope.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Overly-Bearden silty clay loams, moderately saline:				
Overly soil	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Bearden soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained; texture of surface layer.	Moderate: somewhat poorly drained; texture of surface layer.
Overly-Bearden silt loams, moderately saline:				
Overly soil	None to slight	None to slight	None to slight	None to slight.
Bearden soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Parnell silty clay loam	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained.
Parnell and Tonka silty clay loams:				
Parnell soil	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.
Tonka soil	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.
Peat	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.
Peever-Forman clay loams	Moderate: moderately slow and slow permeability; texture of surface layer.	Moderate: moderately slow and slow permeability; texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer
Perella loam, moderately deep over clay.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Perella silty clay loam, moderately deep over clay.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.	Severe: poorly drained.
Roliss clay loam	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.
Ryan-Fargo complex:				
Ryan soil	Severe: very slow permeability; texture of surface layer; poorly drained.	Severe: very slow permeability; texture of surface layer; poorly drained.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Fargo soil	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.	Severe: poorly drained; texture of surface layer.
Serden loamy fine sand	Moderate to severe: slope; texture of surface layer.	Moderate to severe: slope.	Moderate to severe: slope.	Moderate: texture of surface layer.
Serden-Stabilized dune land complex.	Moderate to severe: slope; texture of surface layer.	Moderate to severe: slope.	Moderate to severe: slope.	Moderate: texture of surface layer.
Sioux-Renshaw complex, undulating.	Slight to moderate: slope.	None to slight	None to slight	None to slight.
Sioux-Renshaw complex, hilly	Severe: slope	Slight to severe: slope.	Slight to severe: slope.	Slight to moderate: slope.
Stirum-Arveson loams	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.

TABLE 5.—*Degree and kinds of limitations for recreational facilities*—Continued

Soil	Playgrounds	Camp areas	Picnic areas	Paths and trails
Strongly saline land	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.	Severe: poorly drained.
Svea loam	None to slight	None to slight	None to slight	None to slight.
Svea-Buse loams, undulating	Moderate: slope	None to slight	None to slight	None to slight.
Svea-Buse loams, rolling	Severe: slope	None to slight	None to slight	None to slight.
Svea-Gardena loams	None to slight	None to slight	None to slight	None to slight.
Swenoda-Wyndmere fine sandy loams:				
Swenoda soil	None to slight	None to slight	None to slight	None to slight.
Wyndmere soil	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tiffany fine sandy loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Tiffany loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Tiffany loam, moderately deep over clay.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Tonka silt loam	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Towner loamy fine sand	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.	Moderate: texture of surface layer.
Towner and Swenoda fine sandy loams.	None to slight	None to slight	None to slight	None to slight.
Ulen fine sandy loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Vallers clay loam	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Venlo fine sandy loam	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.
Wahpeton silty clay	Severe: flooding; texture of surface layer.	Severe: flooding; texture of surface layer.	Severe: texture of surface layer.	Severe: texture of surface layer.
Wet alluvial land	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.	Severe: very poorly drained; seasonal high water table.
Wyndmere fine sandy loam	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Zell-Eckman silt loams, hilly	Severe: slope	Moderate: slope	Moderate: slope	None to slight.
Zell-Eckman silt loams, steep	Severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to moderate: slope.

erate, or *severe*. It is assumed that a good plant cover can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these, is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little site preparation is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils are not flooded during periods of heavy use and have mild slopes, good drainage, and a surface that is free of rocks and coarse fragments and is firm after rains but not dusty when dry.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils are not flooded during periods of heavy use, have good drainage, and have a nearly level surface that is free of coarse fragments and rock outcrops and is firm after rains but not dusty when dry. If grading and leveling are required, depth over rock is important.

Picnic areas are attractive natural or landscaped tracts used mainly for preparing meals and eating out-

doors. These areas are subject to heavy foot traffic. Most of the vehicular traffic is confined to access roads. The best soils are firm when wet but not dusty when dry; are free from flooding during the season of use; do not have slopes or stones that greatly increase the cost of leveling or of building access roads.

Paths and trails are used for local and cross country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Engineering Uses of the Soils [7]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil-drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 6, 7, 8, and 9, which show, respectively, several estimated soil properties significant in engineering; interpretations for various engineering uses; and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 6 and 7, and it also can be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science that may not be familiar to engineers. The Glossary defines many of the terms commonly used in soil science.

Engineering classification

The two systems most commonly used in classifying samples of soils for engineering are the Unified system used by engineers of the Soil Conservation Service, Department of Defense, and others (*8*), and the AASHO system adopted by the American Association of State Highway Officials (*1*).

The Unified system is used to classify soils according to engineering uses for building material or for the support of structures other than highways. Soils are classified according to particle-size distribution, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes. There are eight classes of coarse-grained soils that are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. There is one class of highly organic soils, Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL–ML.

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–7 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 9; the estimated classification, without group index numbers, is given in table 6 for all soils mapped in the survey area.

[7] R. R. Boone and C. R. Johnson, engineers, Soil Conservation Service, helped prepare this section.

TABLE 6.—*Estimates of soil properties*

[An asterisk in the first column indicates at at least one mapping unit in this series is made up of two or more kinds of soil. carefully the instructions for referring to other series that appear in the first

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification: Unified	Classification: AASHO	Coarse fraction more than 3 inches in diameter
	Feet	*Inches*				*Percent*
*Aastad: Af	>5	0–12	Loam	CL	A–6	0
For Forman part of Af, see Forman series.		12–60	Clay loam, loam	CL	A–6 or A–7	0
*Aberdeen: Ah, Ak, Ao	2–3	0–11	Silty clay loam	CL	A–6 or A–7	0
For Galchutt part of Ak, see Galchutt series; for Ryan part of Ao, see Ryan series.		11–60	Silty clay or clay	CH	A–7	0
Ag	2–3	0–12	Fine sandy loam	SM or ML	A–4	0
		12–60	Silty clay or clay	CH	A–7	0
*Antler: Ar, As	1–4	0–16	Silty clay loam	CL	A–6 or A–7	0
For Tonka part of As, see Tonka series.		16–60	Clay loam	CL	A–6 or A–7	<5
*Arveson: At, Au, Av	0–3	0–20	Fine sandy loam, loam	SM or ML	A–4	0
For Fossum part, see Fossum series.		20–60	Loamy fine sand, fine sandy loam.	SM	A–2 or A–4	0
Arvilla: Aw	>5	0–15	Sandy loam	SM	A–2	0
		15–60	Coarse sand and gravel	SP–SM	A–1	0
*Barnes: BbD, BbD2, BcD, BdB	>5	0–20	Loam	ML or CL	A–4 or A–6	0
For Buse part of BbD, BbD2 and BcD, see Buse series; for Langhei part of BcD, see Langhei series; for Svea part of BdB, see Svea series.		20–60	Loam or clay loam	CL	A–6	0
*Bearden: Bf	3–5	0–10	Silty loam or silty clay loam	ML or CL	A–4, A–6 or A–7	0
		10–60	Silty loam or silty clay loam	ML or CL	A–6 or A–7	0
Bg	3–5	0–30	Silt loam	ML	A–4	0
For Glyndon part of Bg, see Gt in Glyndon series.		30–60	Silty clay or clay	CH	A–7	0
Beotia	>5	0–60	Silty clay loam	CL	A–6 or A–7	0
Mapped only with Overly soils.						
Borup: Bo, Br	0–3	0–20	Loam or silt loam	ML	A–4	0
		20–60	Very fine sandy loam	ML	A–4	0
Buse	>10	0–6	Loam	CL or ML	A–4 or A–6	0
Mapped with Barnes, Forman, and Svea soils.		6–60	Loam or clay loam	CL	A–6	0
Cashel: Ca	>5	0–60	Silty clay	CH	A–7	0
Colvin: Co	1–3	0–60	Silty clay loam	CL	A–6 or A–7	0
*Dickey: DkB	>5	0–12	Fine sandy loam	SM or ML	A–4	0
For Towner part of DkB, see Towner series.		12–34	Loamy sand	SM	A–2	0
		34–60	Loam, clay loam, or silt loam	CL or ML	A–6 or A–4	0

significant in engineering

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow column of this table. The symbol > means more than, the symbol < means less than]

Percentage less than 3 inches in diameter passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
95–100	95–100	85–95	55–75	25–40	11–22	0.6–2.0	0.20–0.22	6.6–7.3	Moderate	High	Low.
100	90–100	85–95	65–80	30–45	12–25	0.2–0.6	0.14–0.19	6.6–7.8	Moderate to high.	High	Low.
—	100	95–100	85–95	25–50	12–25	0.06–0.2	0.18–0.23	6.1–6.5	Moderate to high.	High	Low.
—	100	90–100	75–95	50–70	25–45	0.06–0.2	0.13–0.17	7.4–8.4	High	High	Low.
100	95–100	70–85	40–55	20–40	0–10	2.0–6.0	0.16–0.18	7.4–8.4	Low	High	Low.
—	100	90–100	75–95	50–70	25–45	0.06–0.2	0.13–0.17	7.4–8.4	High	High	Low.
—	100	95–100	80–95	25–50	12–30	0.2–0.6	0.18–0.23	7.4–7.8	High	High	Low.
95–100	90–100	80–90	65–80	20–40	12–25	0.06–0.2	0.14–0.19	7.4–8.4	Moderate to high.	High	Low.
100	95–100	70–95	40–75	20–40	0–10	2.0–6.0	0.16–0.22	7.4–8.4	Low	Moderate.	Low.
100	95–100	60–80	20–45	20–40	0–10	2.0–6.0	0.09–0.17	7.4–8.4	Low	Moderate.	Low.
100	95–100	60–70	30–40	20–35	0–10	2.0–6.0	0.13–0.15	6.6–7.3	Low	Moderate.	Low.
85–95	60–80	30–50	5–10	[1] NP	NP	>20	0.02–0.05	7.4–7.8	Low	Moderate.	Low.
95–100	90–100	80–95	60–75	25–40	4–20	0.6–2.0	0.20–0.22	6.6–7.3	Low to moderate.	Moderate.	Low.
95–100	90–100	80–95	60–80	20–40	12–25	0.2–0.6	0.14–0.19	7.4–7.8	Moderate	High	Low.
—	100	95–100	80–95	25–50	4–25	0.2–0.6	0.18–0.24	7.4–7.8	Moderate to high.	High	Low.
—	100	90–100	75–95	25–50	4–25	0.2–0.6	0.16–0.22	7.4–8.4	Moderate to high.	High	Low.
—	100	90–100	70–90	25–40	2–10	0.2–0.6	0.20–0.24	7.4–7.8	Low to moderate.	Moderate.	Low.
—	100	95–100	75–95	50–70	25–45	0.06–0.2	0.13–0.17	7.9–8.4	High	High	Low.
—	100	95–100	80–95	30–50	10–25	0.6–2.0	0.16–0.23	6.6–7.8	Moderate	High	Low.
95–100	95–100	85–95	65–85	20–35	0–10	0.6–2.0	0.17–0.22	7.4–7.8	Low	Moderate.	Low.
—	100	85–95	50–65	15–30	0–5	2.0–6.0	0.17–0.19	7.4–7.8	Low	Moderate.	Low.
90–100	80–95	75–90	60–75	20–40	4–20	0.2–0.6	0.20–0.22	6.6–7.3	Low to moderate.	High	Low.
90–100	80–95	75–90	60–80	20–40	12–25	0.2–0.6	0.17–0.19	7.4–7.8	Moderate	High	Low.
—	100	95–100	90–95	50–70	25–45	0.2–0.6	0.13–0.18	7.4–7.8	High	High	Low.
—	100	90–100	80–95	25–50	12–30	0.2–0.6	0.16–0.23	6.6–7.8	Moderate	High	Low.
100	95–100	85–90	40–55	20–40	0–10	6.0–20	0.16–0.18	6.6–7.3	Low	Moderate.	Low.
—	100	50–75	15–30	10–30	0–5	6.0–20	0.09–0.11	6.6–7.3	Low	Moderate.	Low.
95–100	90–100	85–95	60–85	20–40	4–25	0.2–0.6	0.17–0.19	7.4–7.8	Moderate	High	Low.

TABLE 6.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction more than 3 inches in diameter
				Unified	AASHO	
	Feet	*Inches*				*Percent*
*Doran: Do, Dp, Dt. For Perella part of Dp, see Perella series; for Tonka part of Dt, see Tonka series.	3–5	0–9	Clay loam or silty clay loam	CL	A–6 or A–7	0
		9–15	Clay	CH	A–7	0
		15–60	Clay loam	CL	A–6	0
Dovray: Dv	0–3	0–24	Silty clay	CH	A–7	0
		24–60	Clay	CH	A–7	0
*Eckman: EeC. For Zell part of EeC, see Zell series.	>5	0–19	Silt loam	ML	A–4	0
		19–48	Silt loam	ML	A–4	0
		48–60	Very fine sandy loam or silt loam.	ML	A–4	0
*Egeland: EmB. For Maddock part of EmB, see Maddock series.	>5	0–36	Fine sandy loam	SM or ML	A–4	0
		36–60	Fine sandy loam or loamy fine sand.	SM	A–4 or A–2	0
*Embden: En, Et. For Tiffany part of En and Et, see Td in Tiffany series.	3–5	0–36	Fine sandy loam or loam	SM or ML	A–2 or A–4	0
		36–60	Fine sandy loam or loamy fine sand.	SM	A–2 or A–4	0
Enloe. Mapped only with Fargo soils.	1–3	0–14	Silty clay loam	CL	A–7	0
		14–60	Clay	CH	A–7	0
*Exline: Ey. For Ryan part of Ey, see Ryan series.	2–5	0–5	Silt loam	CL	A–6	0
		5–37	Silty clay loam	CL	A–7	0
		37–60	Silt loam or silty clay loam	CL	A–6	0
Fairdale: Fa, Fb, Fd	>5	0–60	Silt loam or silty clay loam	ML or CL	A–4 or A–7	0
*Fargo: Fe, Ff, Fg, FhB, Fk, Fm, Fn, Fo, Fp, Fr, Fs. For Enloe part of Fm and Fn, see Enloe series; for Hegne part of Fo and Fp, see Hegne series; for Ryan part of Fr and Fs, see Ryan series.	3–5	0–8	Silty clay loam or silty clay	CH	A–7	0
		8–60	Clay	CH	A–7	0
*Fordville: Ft. For Renshaw part of Ft, see Renshaw series.	>5	0–24	Loam	ML	A–4	0
		24–60	Coarse sand and gravel	SP–SM	A–1	0
*Forman: FuB, FuB2, FvC, FvC2, FwB. For Aastad part of FuB and FuB2, see Aastad series; for Buse part of FvC and FvC2, see Buse series; for Peever part of FwB, see Peever series.	>5	0–7	Loam or clay loam	CL	A–6	0
		7–60	Clay loam	ML or CL	A–6 or A–7	0
Fossum: Fx	0–3	0–12	Fine sandy loam or loam	SM or ML	A–4	0
		12–60	Loamy fine sand or fine sand	SM	A–2	0
*Galchutt: Ga, Gc, Gd. For Enloe part of Gc, see Enloe series; for Fargo part of Gc, see Fargo series; for Overly part of Gd, see Overly series.	1–3	0–25	Silt loam or silty clay loam	ML or CL	A–6 or A–7	0
		25–60	Clay	CH	A–7	0

significant in engineering—Continued

Percentage less than 3 inches in diameter passing sieve —				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
100	95–100	85–95	70–95	25–50	10–30	0.2–0.6	0.17–0.19	6.6–7.3	Moderate to high.	High	Low.
—	100	90–100	75–95	50–75	25–50	0.06–0.2	0.14–0.18	6.6–7.3	High	High	Low.
100	95–100	85–100	70–80	25–50	10–20	0.06–0.2	0.14–0.19	7.4–7.8	Moderate to high.	High	Low.
100	100	95–100	90–95	50–75	25–50	0.06–0.2	0.14–0.18	6.6–7.3	High	High	Low.
—	100	90–100	75–95	50–80	25–50	0.06–0.2	0.13–0.17	6.6–7.8	High	High	Low.
—	100	90–100	70–90	15–40	0–10	0.6–2.0	0.22–0.24	6.6–7.3	Low	Moderate.	Low.
—	100	90–100	65–90	20–35	0–10	0.6–2.0	0.20–0.22	7.4–7.8	Low	Moderate.	Low.
—	100	75–95	55–85	25–35	0–10	0.6–2.0	0.17–0.19	6.6–7.3	Low	Moderate.	Low.
—	100	70–85	40–55	NP	NP	2.0–6.0	0.15–0.18	6.1–6.5	Low	Moderate.	Low.
—	100	60–80	20–45	NP	NP	2.0–6.0	0.11–0.16	7.4–7.8	Low	Moderate.	Low.
—	100	70–100	25–35	NP	NP	2.0–6.0	0.15–0.22	6.6–7.3	Low	Moderate.	Low.
—	100	60–80	20–45	NP	NP	2.0–6.0	0.11–0.16	6.6–7.3	Low	Moderate.	Low.
—	100	95–100	85–95	25–50	12–30	0.06–0.2	0.18–0.23	5.6–6.0	High	High	Low.
—	100	90–100	75–95	50–70	25–50	0.06–0.2	0.13–0.17	6.1–7.8	High	High	Low.
—	100	90–100	70–90	20–40	10–20	0.6–2.0	0.22–0.24	6.6–7.3	Moderate	High	Low.
—	100	95–100	85–95	25–50	12–30	<0.06	0.06–0.09	7.9–9.0	High	High	Low.
—	100	90–100	70–90	20–35	10–20	<0.06	0.06–0.09	7.9–8.4	Moderate	High	Low.
—	100	90–100	70–90	20–45	4–25	0.6–2.0	0.16–0.24	7.4–7.8	Moderate to high.	Moderate.	Low.
—	100	95–100	85–95	50–70	25–45	0.06–0.2	0.15–0.23	6.6–7.3	High	High	Low.
—	100	90–100	75–98	50–70	25–45	0.06–0.2	0.13–0.17	6.6–7.8	High	High	Low.
95–100	95–100	85–95	55–65	15–35	0–10	0.6–2.0	0.17–0.22	6.6–7.3	Low	Moderate.	Low.
55–80	45–60	15–40	5–10	NP	NP	>20	0.02–0.04	7.4–7.8	Low	Moderate.	Low.
95–100	90–100	85–95	60–80	25–40	10–25	0.6–2.0	0.17–0.22	6.6–7.3	Moderate	High	Low.
95–100	90–100	85–95	65–95	30–45	10–30	0.2–0.6	0.14–0.19	6.6–7.8	Moderate to high.	High	Low.
95–100	90–100	75–90	40–65	10–30	0–5	6.0–20	0.20–0.22	7.4–7.8	Low	Moderate.	Low.
95–100	90–100	65–80	20–35	NP	NP	6.0–20	0.06–0.13	7.4–7.8	Low	Moderate.	Low.
—	100	90–100	60–90	0–40	0–25	0.6–2.0	0.17–0.24	6.1–7.3	Moderate to high.	High	Low.
—	100	90–100	75–98	50–70	25–50	0.06–0.2	0.13–0.17	6.6–7.8	High	High	Low.

TABLE 6.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction more than 3 inches in diameter
				Unified	AASHO	
	Feet	*Inches*				*Percent*
*Gardena: Ge, GfB, Gh. For Eckman part of GfB, see Eckman series; for Embden part of Gh, see Embden series.	>5	0–12	Silt loam or loam	SM or ML	A–4	0
		12–60	Silt loam or very fine sandy loam.	ML	A–4	0
*Gilby: Gk, Gm, Gn. For Hamerly part of Gn, see Hamerly series.	1–3	0–8	Silt loam or loam	ML or ML–CL	A–4	<1
		8–26	Very fine sandy loam or loam	ML	A–4	<1
		26–60	Clay loam	CL	A–6 or A–7	<3
*Glyndon: Go, Gr, Gu. For Tiffany part of Gr, see Td in Tiffany series; for Wyndmere part of Gu, see Wyndmere series.	3–5	0–8	Silt loam, loam, or very fine sandy loam.	ML	A–4 or A–6	0
		8–60	Silt loam or very fine sandy loam.	ML	A–4	0
Gt. For Tiffany part of Gt, see Th in Tiffany series.	3–5	0–8	Silt loam, loam or very fine sandy loam.	ML	A–4	0
		8–36	Silt loam or very fine sandy loam.	ML	A–4	0
		36–60	Clay or silty clay	CH	A–7	0
Grano: Gw	0–3	0–60	Clay	CH	A–7	0
*Hamar: Ha, Hc, Hf, Hg. For Ulen part of Hf and Hg, see Ulen series.	1–3	0–8	Loamy fine sand or fine sandy loam.	SM	A–2 or A–4	0
		8–60	Loamy fine sand	SM	A–2	0
Hb, He	1–3	0–8	Fine sandy loam or loamy fine sand.	SM	A–2 or A–4	0
		8–30	Loamy fine sand	SM	A–2	0
		30–60	Silty clay or clay	CH	A–7	0
Hamerly: Hh	3–5	0–17	Loam	ML or CL	A–4 or A–6	0
		17–60	Loam	ML or CL	A–4 or A–6	0
*Hecla: Hm, Hm3, Hn, Ho, Hr, Hs. For Hamar part of Hm, Hm3. Hn and Ho, see Ha in Hamar series; for Arveson part of Ho, see Arveson series; for Maddock part of Hr and Hs, see Maddock series.	>5	0–16	Fine sandy loam and/or loamy fine sand.	SM	A–2 or A–4	0
		16–60	Loamy fine sand or fine sand	SM	A–2	0
Hk	>5	0–36	Loamy fine sand	SM–SC	A–2	0
		36–60	Silt loam or silty clay loam	ML or CL	A–4, A–6 or A–7	0
Hegne. Mapped only with Fargo soils.	1–3	0–60	Silty clay	CH	A–7	0
Kratka: Kr	1–3	0–10	Fine sandy loam	SM or ML	A–4	0
		10–26	Loamy fine sand	SM	A–2	0
		26–60	Loam or silt loam	CL	A–6	0

significant in engineering—Continued

Percentage less than 3 inches in diameter passing sieve —				Liquid limit	Plasticity index	Perme-ability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
—	100	90–100	45–85	NP to 30	0–10	0.6–2.0	0.20–0.24	6.6–7.8	Low	Moder-ate.	Low.
—	100	85–100	50–90	20–35	0–10	0.6–2.0	0.17–0.22	6.6–7.8	Low	Moder-ate.	Low.
95–100	95–100	85–95	65–90	10–25	4–10	0.6–2.0	0.20–0.24	6.6–7.3	Low to moder-ate.	Moder-ate.	Low.
95–100	90–100	80–95	50–70	20–35	0–10	0.6–2.0	0.17–0.19	6.6–7.8	Low	Moder-ate.	Low to moder-ate.
95–100	90–100	80–95	65–80	25–40	10–25	0.2–0.6	0.14–0.16	7.4–7.8	Moderate to high.	High	Low to moder-ate.
—	100	85–100	55–80	20–40	0–10	0.6–2.0	0.20–0.24	6.6–8.4	Low	Moder-ate.	Low.
—	100	85–100	50–90	0–40	0–10	0.6–2.0	0.17–0.22	7.4–8.4	Low	Moder-ate.	Low.
—	100	85–100	55–80	20–40	0–10	0.6–2.0	0.20–0.24	6.6–8.4	Low	Moder-ate.	Low.
—	100	85–100	50–85	20–40	0–10	0.6–2.0	0.17–0.24	6.6–8.4	Low	Moder-ate.	Low.
—	100	90–100	75–95	50–70	25–45	0.06–0.2	0.13–0.15	6.6–7.8	High	High	Low.
—	100	90–100	75–95	50–75	25–50	0.06–0.2	0.13–0.18	7.4–7.8	High	High	Low.
—	100	60–75	20–45	20–40	0–10	6.0–20	0.10–0.15	7.4–7.8	Low	Moder-ate.	Low.
—	100	50–75	15–30	NP	NP	6.0–20	0.05–0.13	7.4–7.8	Low	Moder-ate.	Low.
—	100	50–75	20–45	20–35	0–10	6.0–20	0.10–0.18	7.4–7.8	Low	Moder-ate.	Low.
—	100	60–75	15–35	10–35	0–10	6.0–20	0.09–0.11	7.4–7.8	Low	Moder-ate.	Low.
—	100	90–100	75–95	50–70	25–40	0.06–0.2	0.13–0.15	7.4–7.8	High	High	Low.
95–100	90–100	80–95	60–75	20–35	8–20	0.2–2.0	0.17–0.22	7.4–7.8	Low to moder-ate.	High	Low.
95–100	90–100	80–95	60–75	20–35	8–20	0.2–0.6	0.17–0.19	7.4–7.8	Low to moder-ate.	High	Low.
—	100	60–100	16–45	NP	NP	6.0–20	0.09–0.18	6.6–7.3	Low	Moder-ate.	Low.
—	100	60–100	12–35	NP	NP	6.0–20	0.06–0.13	6.6–7.3	Low	Moder-ate.	Low.
—	100	60–75	15–35	10–25	4–7	6.0–20	0.09–0.12	6.6–7.3	Low	Moder-ate.	Low.
—	100	90–100	70–95	25–50	8–35	0.2–0.6	0.16–0.22	6.6–7.3	Moderate to high.	High	Low.
—	100	95–100	90–95	50–70	25–45	0.06–0.2	0.13–0.18	6.6–7.8	High	High	High.
—	100	70–85	40–55	NP	NP	6.0–20	0.16–0.18	6.6–7.8	Low	Moder-ate.	Low.
—	100	50–75	15–30	NP	NP	6.0–20	0.10–0.13	6.6–7.8	Low	Moder-ate.	Low.
100	95–100	85–100	60–90	20–40	10–25	0.2–0.6	0.17–0.22	7.4–7.8	Moderate	High	Low.

TABLE 6.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction more than 3 inches in diameter
				Unified	AASHO	
	Feet	*Inches*				*Percent*
*LaDelle: La, Lb. For Wahpeton part of Lb, see Wahpeton series.	>4	0–60	Silty clay loam	CL	A–6 or A–7	0
Lamoure: Lm	2–5	0–60	Silty clay loam	CL	A–6 or A–7	0
Langhei. Mapped only with Barnes and Buse soils.	10	0–7	Loam	ML or CL	A–4 or A–6	0
		7–60	Clay loam or loam	CL	A–6 or A–7	0
LaPrairie: Lp	>5	0–35	Silt loam or loam	ML–CL or CL	A–4 or A–6	0
		35–60	Silt loam, loam, or clay loam	ML or CL	A–4, A–6 or A–7	0
*Maddock: MdC, MhB, MlB. For Hecla part of MhB and MlB, see Hecla series; for Hamar part of MlB, see Ho in Hamar series.	>5	0–14	Loamy fine sand, loamy sand, sandy loam, or fine sandy loam.	SM	A–2 or A–4	0
		14–60	Fine sand or loamy fine sand	SM	A–2	0
Marsh: Mr. Properties are too variable to be rated.						
Nutley: NuC	>5	0–5	Silty clay	CH	A–7	0
		5–60	Clay	CH	A–7	0
*Overly: Oc, Od, Oe, OlB. For Bearden part of Od and Oe, see Bg in Bearden series; for Beotia part of OlB, see Beotia series.	>5	0–24	Silt loam or silty clay loam	CL	A–6 or A–7	0
		24–60	Silt loam or silty clay loam	CL	A–6 or A–7	0
*Parnell: Pc, Pd. For Tonka part of Pd, see Tonka series.	0–3	0–34	Silty clay loam	CL	A–6 or A–7	0
		34–60	Clay loam	CL	A–6 or A–7	0
Peat: Pe. Properties are too variable to be rated.						
*Peever: Pf. For Forman part of Pf, see Forman series.	3–5	0–7	Clay loam	CL	A–6 or A–7	0
		7–19	Silty clay	CH	A–7	0
		19–60	Clay loam	CL	A–6	0
Perella: Pr, Ps	1–3	0–32	Loam, clay loam, silty clay loam	ML or CL	A–4, A–6 or A–7	0
		32–60	Silty clay	CH	A–7	0
Renshaw. Mapped only with Fordville and Sioux soils.	>5	0–18	Loam	ML	A–4	0
		18–60	Coarse sand and gravel	GM or SM	A–1 or A–2	0
Roliss: Ro	0–3	0–60	Clay loam	CL	A–6 or A–7	0
*Ryan: Ry. For Fargo part of Ry, see Fargo series.	2–5	0–5	Silty clay or silty clay loam	CL	A–6 or A–7	0
		5–60	Silty clay	CH	A–7	0

significant in engineering—Continued

Percentage less than 3 inches in diameter passing sieve —				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
—	100	95–100	85–95	25–50	12–30	0.6–2.0	0.16–0.23	6.6–7.8	Moderate	High	Low.
—	100	95–100	85–95	25–50	12–30	0.6–2.0	0.16–0.23	7.4–7.8	High	High	Low.
90–100	85–100	80–90	60–75	70–40	4–25	0.2–0.6	0.20–0.22	7.4–7.8	Low to moderate.	Moderate.	Low.
95–100	90–100	85–95	65–80	20–45	12–25	0.2–0.6	0.14–0.19	7.4–7.8	Moderate to high.	High	Low.
—	100	90–100	70–90	17–40	4–20	0.6–2.0	0.17–0.24	6.6–7.8	Low to moderate.	Moderate.	Low.
—	100	85–100	65–90	25–45	4–25	0.6–2.0	0.14–0.22	6.6–7.8	Low to moderate.	Moderate.	Low.
—	100	50–75	20–40	NP	NP	6.0–20	0.10–0.18	6.6–7.3	Low	Moderate.	Low.
—	100	55–75	15–35	NP	NP	6.0–20	0.05–0.10	6.6–7.8	Low	Moderate.	Low.
—	100	95–100	90–95	50–70	25–45	0.06–0.2	0.15–0.18	6.1–6.5	High	High	Low.
—	100	90–100	75–95	50–70	25–45	0.06–0.2	0.13–0.17	7.4–8.4	High	High	Low.
—	100	95–100	75–95	25–50	10–30	0.2–0.6	0.18–0.24	6.6–7.8	Moderate to high.	High	Low.
—	100	95–100	85–95	25–50	10–30	0.2–0.6	0.16–0.21	6.6–7.3	Moderate to high.	High	Low.
—	100	95–100	85–95	25–50	12–30	0.06–0.2	0.16–0.23	6.1–7.[illegible]	High	High	Low.
100	95–100	90–100	70–80	30–45	12–25	0.06–0.2	0.14–0.19	7.4–7.[illegible]	Moderate to high.	High	Low.
95–100	90–100	85–95	70–80	25–45	12–25	0.6–2.0	0.17–0.19	6.1–6.[illegible]	Moderate to high.	High	Low.
90–100	90–100	85–95	80–95	50–75	25–55	0.06–0.2	0.14–0.17	6.6–7.[illegible]	High	High	Low.
95–100	90–100	85–95	70–80	25–45	12–25	0.2–0.6	0.14–0.19	7.4–7.[illegible]	Moderate to high.	High	Low.
95–100	90–100	80–100	60–95	25–50	4–30	0.2–0.6	0.15–0.23	6.6–7.3	Moderate to high.	High	Low.
—	100	95–100	90–95	50–70	25–45	0.06–0.2	0.13–0.15	7.4–7.8	High	High	Low.
100	95–100	85–95	60–75	15–40	0–10	2.0–6.0	0.17–0.22	6.6–7.3	Low	Moderate.	Low.
30–70	15–50	10–40	3–25	NP	NP	>20	0.02–0.05	7.4–7.8	Low	Moderate.	Low.
95–100	90–100	85–95	65–80	20–45	10–25	0.2–0.6	0.14–0.19	6.6–7.8	Moderate to high.	High	Low.
—	100	95–100	85–95	25–50	10–30	<0.06	0.15–0.23	6.6–7.3	High	High	Low.
—	100	95–100	90–95	50–70	25–40	<0.06	0.10–0.14	7.4–8.4	High	High	Moderate.

TABLE 6.—*Estimate of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction more than 3 inches in diameter
				Unified	AASHO	
	Feet	*Inches*				*Percent*
Serden: Sd, Se	>5	0–8	Fine sand and loamy fine sand	SM	A–2	0
Stabilized dune land part of Se is too variable to be rated.		8–60	Fine sand	SM	A–2	0
*Sioux: ShB, ShE	>5	0–8	Sandy loam	SM	A–2	<1
For Renshaw part of ShB and ShE, see Renshaw series.		8–60	Loamy coarse sand, coarse sand, and gravel.	GM or SM	A–1	<5
Stabilized dune land. Mapped only with Searden soils. Properties too variable to be rated.						
*Stirum: Sr	1–3	0–7	Loam	ML	A–4	0
For Arveson part of Sr, see Arveson series.		7–27	Sandy clay loam	ML	A–4	0
		27–60	Fine sandy loam or loamy fine sand.	SM	A–2 or A–4	0
Strongly saline land: St. Properties are too variable to be rated.						
*Svea: Su, SvB, SvC, Sw	>5	0–11	Loam	ML	A–4	0
For Buse part of SvB and SvC, see Buse series; for Gardena part of Sw, see Gardena series.		11–60	Loam or clay loam	ML, CL ML–CL	A–4 or A–6	<1
*Swenoda: Sy	3–5	0–26	Fine sandy loam	SM	A–4	0
For Wyndmere part of Sy, see Wyndmere series.		26–60	Loam, silt loam, clay loam, silty clay loam, or silty clay.	CL or CH	A–6 or A–7	0
Tiffany:						
Td, Tf	1–3	0–7	Loam, very fine sandy loam, or fine sandy loam.	ML or SM	A–4	0
		7–60	Fine sandy loam, loamy fine sand.	SM or ML	A–4	0
Th	1–3	0–24	Loam or fine sandy loam	SM or ML	A–4	0
		24–60	Clay or silty clay	CH	A–7	0
Tonka: Tk	0–5	0–27	Silty loam or silty clay loam	CL	A–6 or A–7	0
		27–38	Silty clay loam	CL	A–6 or A–7	0
		38–60	Silt loam or clay loam	CL	A–6 or A–7	0
*Towner: To, Tw	3–5	0–28	Fine sandy loam or loamy fine sand.	SM	A–2 or A–7	0
For Swenoda part of Tw, see Swenoda series.		28–60	Loam, clay loam, silt loam, silty clay loam, clay.	ML, CL or CH	A–4, A–6, or A–7	0
Ulen: Un	2–5	0–16	Loamy fine sand or fine sandy loam.	SM	A–2 or A–4	0
		16–60	Loamy fine sand or fine sand	SM	A–2	0
Vallers: Va	1–3	0–60	Clay loam	CL	A–6 or A–7	0
Venlo: Ve	0–3	0–13	Fine sandy loam	SM or ML	A–4	0
		13–60	Fine sand	SM	A–2	0
Wahpeton: Wa	>5	0–60	Silty clay	CH	A–7	0

significant in engineering—Continued

Percentage less than 3 inches in diameter passing sieve —				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
—	100	65–85	15–30	NP	NP	6.0–20	0.07–0.12	6.6–7.3	Low	Moderate.	Low.
—	100	65–80	20–35	NP	NP	6.0–20	0.05–0.08	6.6–7.3	Low	Moderate.	Low.
100	95–100	60–70	25–35	20–35	0–8	6.0–20	0.13–0.15	6.6–7.3	Low	Moderate.	Low.
25–75	20–50	10–35	5–25	NP	NP	>20	0.02–0.05	7.4–7.8	Low	Moderate.	Low.
—	100	85–100	60–75	NP to 35	NP to 10	0.2–0.6	0.20–0.22	7.9–8.4	Low	Moderate.	Low.
—	100	80–100	35–65	NP to 40	NP to 10	0.2–0.6	0.05–0.09	8.5–9.0	Moderate	High	Low.
—	100	60–100	12–50	NP	NP	2.0–6.0	0.05–0.08	7.9–9.0	Low	Moderate.	Low.
100	95–100	80–95	60–75	20–35	0–10	0.6–2.0	0.20–0.22	6.6–7.3	Low	High	Low.
95–100	95–100	85–95	55–80	20–40	5–25	0.2–2.0	0.14–0.19	6.6–7.8	Moderate	Moderate to high.	Low.
100	90–100	70–85	35–50	20–35	0–10	2.0–6.0	0.10–0.16	6.6–7.3	Low	Moderate.	Low.
95–100	95–100	85–100	60–95	25–70	10–40	0.06–0.6	0.13–0.19	7.4–7.8	Moderate to high.	High	Low.
100	95–100	70–95	40–75	20–35	0–10	2.0–6.0	0.10–0.22	6.6–7.3	Low	Moderate.	Low.
—	100	70–85	40–55	20–35	0–10	2.0–6.0	0.08–0.17	6.6–7.3	Low	Moderate.	Low.
—	100	70–90	40–70	20–35	0–10	2.0–6.0	0.16–0.22	6.6–7.3	Low	Moderate.	Low.
—	100	90–100	75–95	50–70	25–45	0.06–0.2	0.13–0.17	6.6–7.8	High	High	Low.
—	100	90–100	70–90	20–45	12–25	0.06–0.2	0.17–0.29	5.6–6.5	Low to moderate.	High	Low.
100	95–100	90–100	85–95	30–50	12–35	0.06–0.2	0.16–0.20	6.1–6.5	High	High	Low.
—	100	90–100	70–90	25–50	10–25	0.06–0.2	0.14–0.22	6.6–7.3	High	High	Low.
100	95–100	60–80	20–45	NP	NP	6.0–20	0.10–0.18	6.6–7.3	Low	Moderate.	Low.
100	95–100	85–100	60–95	25–65	4–40	0.06–0.6	0.13–0.22	7.4–7.8	Moderate to high.	Moderate.	Low.
100	100	60–80	20–45	20–35	0–10	6.0–20	0.16–0.18	7.4–7.8	Low	Moderate.	Low.
100	100	50–80	15–35	NP	NP	6.0–20	0.05–0.11	7.4–7.8	Low	Moderate.	Low.
100	95–100	90–100	70–80	25–45	10–25	0.2–0.6	0.14–0.19	7.4–7.8	Moderate	High	Low.
100	100	70–85	40–55	NP	NP	6.0–20	0.16–0.18	6.6–7.3	Low	Moderate.	Low.
100	100	65–80	20–35	NP	NP	6.0–20	0.05–0.08	6.6–7.3	Low	Moderate.	Low.
100	100	95–100	90–95	50–75	25–50	0.2–0.6	0.13–0.18	6.6–7.3	High	High	Low.

TABLE 6.—*Estimate of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction more than 3 inches in diameter
				Unified	AASHO	
	Feet	*Inches*				*Percent*
Wet alluvial land: We. Properties are too variable to be rated.						
Wyndmere: Wy	2–5	0–8	Loam or fine sandy loam	ML or SM	A–4	0
		8–60	Fine sandy loam	ML or SM	A–4	0
*Zell: ZeD, ZeE. For Eckman part of ZeD and ZeE, see Eckman series.	>5	0–60	Silt loam	ML	A–4	0

[1] NP is nonplastic.

TABLE 7.—*Soil interpretations*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. carefully the instructions for referring to other

Soil series and map symbols	Degree and kind of limitation for—		
	Septic tank absorption fields	Sewage lagoons	Shallow excavations
*Aastad: Af. For Forman part of Af, see Forman series.	Severe: moderately slow permeability.	Slight	Moderate: moderately well drained.
*Aberdeen: Ag, Ah, Ak, Ao. For Galchutt part of Ak, see Galchutt series; for Ryan part of Ao, see Ryan series.	Severe: slow permeability	Slight	Severe: somewhat poorly drained.
*Antler: Ar, As. For Tonka part of As, see Tonka series.	Severe: moderately slow to slow permeability.	Moderate: seasonal high water table.	Severe: somewhat poorly drained.
*Arveson: At, Au, Av. For Fossum part of At, Au, and Av, see Fossum series.	Severe: seasonal high water table.	Severe: seasonal high water table; moderately rapid permeability.	Severe: poorly drained and very poorly drained; seasonal high water table.
Arvilla: Aw	Slight: potential pollution hazard.	Severe: very rapid permeability.	Moderate: gravelly substratum.
*Barnes: BbD, BbD2, BcD, BdB. For Buse part of BbD, BbD2, and BcD, see Buse series; for Langhei part of BcD, see Langhei series; for Svea part of BdB, see Svea series.	Severe: moderately slow permeability in substratum.	Moderate if slope is less than 6 percent, severe if more than 6 percent.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent, severe if more than 15 percent.
*Bearden:			
Bf	Severe: moderately slow permeability; seasonal high water table.	Moderate: seasonal high water table.	Severe: somewhat poorly drained.
Bg. For Glyndon part of Bg, see Gt in Glyndon series.	Severe: slow permeability in substratum; seasonal high water table.	Moderate: seasonal high water table.	Severe: somewhat poorly drained; poor workability in substratum.
Bearden part of Overly-Bearden complex.	Severe: moderately slow permeability; seasonal high water table.	Moderate: seasonal high water table.	Severe: somewhat poorly drained.

significant in engineering—Continued

Percentage less than 3 inches in diameter passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
100	95–100	70–85	45–65	20–40	0–10	2.0–6.0	0.15–0.21	7.9–8.4	Low	Moderate.	Low.
100	95–100	70–85	40–55	20–40	0–10	2.0–6.0	0.14–0.17	7.9–8.4	Low	Moderate.	Low.
100	100	90–100	70–90	25–40	0–10	0.6–2.0	0.20–0.24	6.6–7.8	Low	Moderate.	Low.

for land-use planning

The soils in such mapping units may have different properties and limitation, and for this reason it is necessary to follow series that appear in the first column of this table]

Degree and kind of limitation for—Continued			
Dwellings with basements	Sanitary landfill trench [1]	Sanitary landfill area	Local streets and roads
Moderate or severe: moderate or high shrink-swell potential.	Slight	Slight	Moderate or severe: moderate or high shrink-swell potential.
Severe: high shrink-swell potential of substratum.	Severe: seasonal high water table; poor workability in substratum.	Moderate: somewhat poorly drained.	Severe: high shrink-swell potential in substratum.
Severe: somewhat poorly drained.	Severe: seasonal high water table.	Severe: seasonal high water table.	Moderate or severe: moderate or high shrink-swell potential.
Severe: poorly drained and very poorly drained.	Severe: poorly drained and very poorly drained; seasonal high water table; moderately rapid permeability.	Severe: poorly drained and very poorly drained; seasonal high water table; moderately rapid permeability.	Severe: poorly drained and very poorly drained.
Slight	Severe: very rapid permeability; potential pollution hazard.	Severe: very rapid permeability; potential pollution hazard.	Slight.
Moderate: moderate shrink-swell potential, severe if slope is more than 15 percent.	Slight if slope is less than 15 percent, moderate if more than 15 percent.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent, severe if more than 15 percent.	Moderate: moderate shrink-swell potential; severe if slope is more than 15 percent.
Severe: somewhat poorly drained.	Severe: seasonal water table at a depth of less than 72 inches.	Moderate: somewhat poorly drained.	Moderate or severe: moderate or high shrink-swell potential.
Severe: somewhat poorly drained; high shrink-swell potential in substratum.	Severe: seasonal high water table; poor workability in substratum.	Moderate: somewhat poorly drained.	Moderate or severe: moderate or high shrink-swell potential.
Severe: somewhat poorly drained.	Severe: seasonal high water table.	Moderate: somewhat poorly drained.	Moderate or severe: moderate or high shrink-swell potential.

TABLE 7.—*Soil interpretations*

Soil series and map symbols	Degree and kind of limitation for— Septic tank absorption fields	Sewage lagoons	Shallow excavations
Beotia. Mapped only with Overly soils.	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight.
Borup: Bo, Br	Severe: seasonal high water table.	Severe: moderately rapid permeability in substratum; seasonal high water table.	Severe: poorly drained; seasonal high water table.
Buse. Mapped with Barnes, Forman, and Svea soils.	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Slight if slope is less than 8 percent; moderate if 8 to 15 percent; severe if more than 15 percent.
Cashel: Ca	Severe: moderately slow permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Colvin: Co	Severe: moderately slow permeability; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained; seasonal high water table.
*Dickey: DkB. For Towner part of DkB, see Towner series.	Severe: moderately slow permeability in substratum.	Slight	Slight. Moderate in clay loam substratum; moderately poor workability.
*Doran: Do, Dp, Dt. For Perella part of Dp, see Perella series; for Tonka part of Dt, see Tonka series.	Severe: moderately slow to slow permeability.	Slight	Severe: somewhat poorly drained; poor workability.
Dovray: Dv	Severe: slow permeability.	Slight	Severe: very poorly drained; clay texture.
*Eckman: EeC. For Zell part of EeC, see Zell series.	Slight if slope is less than 9 percent, moderate if 9 to 15 percent, severe if more than 15 percent.	Moderate if slope is less than 6 percent, severe if more than 6 percent.	Slight if slope is less than 9 percent, moderate if 9 to 15 percent; severe if more than 15 percent.
*Egeland: EmB. For Maddock part of EmB, see Maddock series.	Slight: potential pollution hazard.	Severe: moderately rapid permeability.	Slight.
*Embden: En, Et. For Tiffany part of En and Et, see Td in Tiffany series.	Moderate: seasonal high water table.	Severe: moderately rapid permeability.	Moderate: moderately well drained.
Enloe. Mapped only with Fargo soils.	Severe: slow permeability.	Moderate: high water table.	Severe: poorly drained; poor workability.
*Exline: Ey. For Ryan part of Ey, see Ryan series.	Severe: very slow permeability.	Moderate: seasonal high water table.	Severe: somewhat poorly drained.
Fairdale: Fa, Fb, Fd	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
*Fargo: Fe, Ff, Fg, FhB, Fk, Fm, Fn, Fo, Fp, Fr, Fs. For Enloe part of Fm and Fn, see Enloe series; for Hegne part of Fo and Fp, see Hegne series; for Ryan part of Fr and Fs, see Ryan series.	Severe: slow permeability.	Slight.	Severe: poorly drained; poor workability.
*Fordville: Ft. For Renshaw part of Ft, see Renshaw series.	Slight: potential pollution hazard.	Severe: very rapid permeability in substratum.	Moderate: gravelly substratum.
*Forman: FuB, FuB2, FvC, FvC2, FwB. For Aastad part of FuB and FuB2, see Aastad series; for Buse part of FvC and FvC2, see Buse series; for Peever part of FwB, see Peever series.	Severe: moderately slow permeability in substratum.	Slight if slope is less than 3 percent, moderate if 3 to 6 percent, severe if more than 6 percent.	Moderate: moderately difficult to work.
Fossum: Fx	Severe: seasonal high water table; potential pollution hazard.	Severe: rapid permeability; potential pollution hazard.	Severe: poorly drained; seasonal high water table.
*Galchutt: Ga, Gc, Gd. For Enloe part of Gc, see Enloe series; for Fargo part of Gc, see Fargo series; for Overly part of Gd, see Od in Overly series.	Severe: slow permeability in substratum.	Moderate: seasonal high water table.	Severe: somewhat poorly drained; poor workability in substratum.

for land-use planning—Continued

Degree and kind of limitation for—Continued			
Dwellings with basements	Sanitary landfill trench [1]	Sanitary landfill area	Local streets and roads
Moderate: moderate potential frost action.	Moderate: silty clay loam texture.	Slight	Moderate: moderate shrink-swell potential.
Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained	Severe: poorly drained.
Moderate: moderate shrink-swell potential; severe if more than 15 percent slope.	Slight if slope is less than 15 percent; moderate if more than 15 percent.	Slight if slope is less than 8 percent; moderate if 8 to 15 percent; severe if more than 15 percent.	Moderate: moderate shrink-swell potential; severe if more than 15 percent slope.
Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding; high shrink-swell potential.
Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained	Severe: poorly drained.
Moderate: moderate shrink-swell potential.	Slight. Moderate in clay loam substratum; moderately poor workability.	Slight	Moderate: moderate shrink-swell potential.
Severe: somewhat poorly drained; high potential frost action.	Severe: seasonal high water table; poor workability.	Moderate: somewhat poorly drained; seasonal high water table.	Severe: high potential frost action.
Severe: very poorly drained; high shrink-swell potential.	Severe: very poorly drained; poor workability.	Severe: very poorly drained	Severe: very poorly drained; high shrink-swell potential.
Slight if slope is 0 to 9 percent, moderate if 9 to 15 percent.	Slight: 0 to 15 percent slope	Slight if slope is less than 9 percent; moderate if 9 to 15 percent.	Moderate: ML material.
Slight	Severe: moderately rapid permeability; pollution hazard.	Severe: moderately rapid permeability; pollution hazard.	Slight: moderate if ML material.
Moderate: moderately well drained.	Severe: moderately rapid permeability; potential pollution hazard.	Severe: moderately rapid permeability; potential pollution hazard.	Slight or moderate. Moderate if more than 30 percent fines.
Severe: poorly drained	Severe: poorly drained; poor workability.	Severe: poorly drained	Severe: poorly drained; high shrink-swell potential.
Severe: somewhat poorly drained.	Severe: seasonal high water table.	Moderate: somewhat poorly drained.	Severe: high potential frost action.
Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding.
Severe: high shrink-swell potential; poorly drained.	Severe: poorly drained; poor workability.	Severe: poorly drained	Severe: high shrink-swell potential.
Slight	Severe: very rapid permeability in substratum; potential pollution hazard.	Severe: very rapid permeability in substratum; potential pollution hazard.	Slight.
Moderate or severe: moderate or high shrink-swell potential.	Moderate: clay loam texture.	Slight	Moderate or severe: moderate or high shrink-swell potential.
Severe: poorly drained; seasonal high water table.	Severe: rapid permeability; seasonal high water table; potential pollution hazard.	Severe: rapid permeability; seasonal high water table; potential pollution hazard.	Severe: poorly drained.
Severe: somewhat poorly drained; high potential frost action.	Severe: seasonal high water table; poor workability in substratum.	Moderate: somewhat poorly drained.	Severe: high shrink-swell potential.

TABLE 7.—*Soil interpretations*

Soil series and map symbols	Degree and kind of limitation for—		
	Septic tank absorption fields	Sewage lagoons	Shallow excavations
*Gardena: Ge, GfB, Gh. For Eckman part of GfB, see Eckman series; for Embden part of Gh, see Embden series.	Slight or moderate: moderate permeability.	Moderate: moderate permeability.	Moderate: moderately well drained.
*Gilby:			
Gk, Gn. For Hamerly part of Gn, see Hamerly series.	Severe: moderately slow permeability in substratum.	Moderate: seasonal high water table.	Severe: somewhat poorly drained; seasonal high water table.
Gm	Severe: moderately slow permeability in substratum.	Moderate: seasonal high water table.	Severe: somewhat poorly drained; seasonal high water table.
*Glyndon:			
Go, Gr, Gu. For Tiffany part of Gr, see Td in Tiffany series; for Wyndmere part of Gu, see Wyndmere series.	Severe: seasonal high water table.	Moderate: seasonal high water table.	Severe: somewhat poorly drained.
Gt. For Tiffany part of Gt, see Th in Tiffany series.	Severe: slow permeability in substratum; seasonal high water table.	Moderate: seasonal high water table.	Severe: somewhat poorly drained; poor workability in substratum.
Grano: Gw	Severe: slow permeability	Moderate: seasonal high water table.	Severe: very poorly drained
*Hamar:			
Ha, Hc, Hf, Hg. For Ulen part of Hf and Hg, see Ulen series.	Severe: seasonal high water table; potential pollution hazard.	Severe: rapid permeability; seasonal high water table.	Severe: seasonal high water table.
Hb, He	Severe: seasonal high water table; slow permeability in substratum.	Moderate: seasonal high water table.	Severe: poorly drained; poor workability in substratum.
Hamerly: Hh	Severe: moderately slow permeability in substratum.	Moderate: seasonal high water table.	Severe: somewhat poorly drained.
*Hecla:			
Hm, Hm3, Hn, Ho, Hr, Hs. For Hamar part of Hm, Hm3, Hn and Ho, see Ha in Hamar series; for Arveson part of Ho, see Arveson series; for Maddock part of Hr and Hs, see Maddock series.	Slight: potential pollution hazard.	Severe: rapid permeability	Severe: sandy texture
Hk	Moderate: moderately slow permeability in substratum.	Moderate: rapid permeability to a depth of 36 inches.	Moderate: moderately well drained.
Hegne. Mapped only with Fargo soils.	Severe: slow permeability	Slight	Severe: poorly drained; poor workability.
Kratka: Kr	Severe: seasonal high water table.	Severe: seasonal high water table; rapid permeability to a depth of 26 inches; moderately slow below.	Severe: poorly drained
*LaDelle: La, Lb. For Wahpeton part of Lb, see Wahpeton series.	Severe: subject to flooding	Moderate: moderate permeability.	Severe: subject to flooding
Lamoure: Lm	Severe: seasonal high water table; subject to flooding.	Severe: subject to flooding	Severe: seasonal high water table; subject to flooding.
Langhei. Mapped only with Barnes and Buse soils.	Severe: moderately slow permeability.	Severe: slope	Moderate if slope is less than 15 percent, severe if more than 15 percent.
LaPrairie: Lp	Severe: subject to flooding	Moderate: moderate permeability.	Severe: subject to flooding
*Maddock: MdC, MhB, MlB. For Hecla part of MhB and MlB, see Hm in Hecla series; for Hamar part of MlB, see Ha in Hamar series.	Slight: potential pollution hazard.	Severe: rapid permeability; pollution hazard.	Severe: sandy texture
Marsh: Mr. Properties too variable to be rated.			
Nutley: NuC	Severe: slow permeability	Moderate if slope is less than 7 percent, severe if more than 7 percent.	Severe: clay texture; poor workability.

for land-use planning—Continued

Degree and kind of limitation for—Continued			
Dwellings with basements	Sanitary landfill trench [1]	Sanitary landfill area	Local streets and roads
Moderate: moderately well drained.	Slight	Slight	Moderate: ML material.
Severe: somewhat poorly drained; seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Moderate to severe: moderate to high shrink-swell potential.
Severe: somewhat poorly drained; seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Moderate to severe: moderate to high shrink-swell potential.
Severe: somewhat poorly drained.	Severe: seasonal high water table.	Moderate: somewhat poorly drained.	Moderate: moderate potential frost action.
Severe: somewhat poorly drained; high shrink-swell potential in substratum.	Severe: seasonal high water table; poor workability in substratum.	Moderate: somewhat poorly drained.	Moderate: moderate potential frost action.
Severe: very poorly drained	Severe: very poorly drained	Severe: very poorly drained	Severe: very poorly drained.
Severe: seasonal high water table.	Severe: seasonal high water table; pollution hazard.	Severe: seasonal high water table.	Severe or moderate: poorly drained or somewhat poorly drained.
Severe: poorly drained; seasonal high water table.	Severe: poorly drained; poor workability in substratum.	Severe: poorly drained	Severe: poorly drained.
Severe: somewhat poorly drained.	Severe: seasonal high water table.	Moderate: somewhat poorly drained; seasonal high water table.	Moderate: moderate potential frost action.
Slight or moderate: moderately well drained.	Severe: rapid permeability; potential pollution hazard.	Severe: rapid permeability; potential pollution hazard.	Slight or moderate. Moderate if more than 30 percent fines.
Moderate: moderately well drained.	Moderate: moderately poor workability in substratum.	Slight	Moderate or severe: moderate to high shrink-swell potential.
Severe: high shrink-swell potential; poorly drained.	Severe: poorly drained; poor workability; seasonal high water table.	Severe: poorly drained	Severe: high shrink-swell potential; poorly drained.
Severe: poorly drained	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding	Moderate: moderate shrink-swell potential.
Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding	Severe: poorly drained; frequently flooded.
Moderate if slope is less than 15 percent; moderate shrink-swell potential; severe if slope is more than 15 percent.	Slight if slope is less than 15 percent, moderate if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent.	Moderate: moderate shrink-swell potential; severe if slope is 15 percent.
Severe: subject to flooding	Severe: subject to flooding	Severe: subject to flooding	Moderate to severe: subject to flooding.
Slight	Severe: rapid permeability; potential pollution hazard.	Severe: rapid permeability; potential pollution hazard.	Slight.
Severe: high shrink-swell potential.	Severe: clay texture; poor workability.	Moderate: slope	Severe: high shrink-swell potential.

TABLE 7.—*Soil interpretations*

Soil series and map symbols	Degree and kind of limitation for— Septic tank absorption fields	Sewage lagoons	Shallow excavations
*Overly:			
Oc, OlB. For Beotia part of OlB, see Beotia series.	Severe: moderately slow permeability.	Slight if slope is less than 2 percent; moderate if 2 to 7 percent.	Moderate: moderately well drained.
Od, Oe. For Bearden part of Od and Oe, see Bearden series.	Severe: moderately slow permeability.	Slight	Moderate: moderately well drained.
*Parnell: Pc, Pd. For Tonka part of Pd, see Tonka series.	Severe: slow permeability; ponded.	Severe: high water table; subject to ponding.	Severe: very poorly drained; frequently ponded.
Peat: Pe. Properties too variable to be rated.			
*Peever: Pf. For Forman part of Pf, see Forman series.	Severe: moderately slow permeability in substratum.	Slight if slope is less than 2 percent, moderate if 2 to 7 percent.	Moderate or severe: clay loam and silty clay texture.
Perella: Pr, Ps	Severe: moderately slow to slow permeability.	Moderate: subject to flooding	Severe: poorly drained
Renshaw. Mapped only with Fordville and Sioux soils.	Slight: potential pollution hazard.	Severe: very rapid permeability in substratum.	Moderate: gravelly substratum.
Roliss: Ro	Severe: moderately slow permeability.	Severe: seasonal high water table; subject to ponding.	Severe: very poorly drained
*Ryan: Ry. For Fargo part of Ry, see Fargo series.	Severe: very slow permeability.	Slight	Severe: clay texture; poor workability.
Serden: Sd, Se. Stabilized dune land part of Se is too variable to be rated.	Slight: potential pollution hazard.	Severe: rapid permeability	Severe: sandy texture
*Sioux: ShB, ShE. For Renshaw part of ShB and ShE, see Renshaw series. Stabilized dune land. Mapped with Searden soils. Properties too variable to be rated.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent, severe if more than 15 percent; potential pollution hazard.	Severe: very rapid permeability.	Moderate: gravelly substratum.
*Stirum: Sr. For Arveson part of Sr, see Arveson series.	Severe: seasonal high water table.	Severe: moderately rapid permeability in substratum; seasonal high water table.	Severe: poorly drained; seasonal high water table.
Strongly saline land: St. Properties too variable to be rated.			
*Svea: Su, SvB, SvC, Sw. For Buse part of SvB and SvC, see Buse series; for Gardena part of Sw, see Gardena series.	Severe: moderately slow permeability in substratum.	Slight if slope is less than 2 percent, moderate if 2 to 7 percent, severe if more than 7 percent.	Moderate: moderately well drained.
*Swenoda: Sy. For Wyndmere part of Sy, see Wyndmere series.	Moderate: moderately slow or slow permeability in substratum.	Slight	Moderate: moderately well drained; severe if substratum is silty clay.
Tiffany:			
Td, Tf	Severe: seasonal high water table.	Severe: moderately rapid permeability.	Severe: poorly drained; seasonal high water table.
Th	Severe: seasonal high water table; slow permeability in substratum.	Moderate: seasonal high water table.	Severe: poorly drained; poor workability in substratum.
Tonka: Tk	Severe: slow permeability; poorly drained.	Slight	Severe: poorly drained; subject to ponding.
*Towner: To, Tw. For Swenoda part of Tw, see Swenoda series.	Moderate: moderately slow or slow permeability in substratum.	Slight	Moderate: clay loam substratum; moderately poor workability. Severe: silty clay substratum; poor workability.
Ulen: Un	Severe: seasonal high water table; potential pollution hazard.	Severe: rapid permeability	Severe: somewhat poorly drained; sandy texture.

for land-use planning—Continued

Degree and kind of limitation for—Continued			
Dwellings with basements	Sanitary landfill trench [1]	Sanitary landfill area	Local streets and roads
Moderate to severe: moderate to high shrink-swell potential.	Moderate: moderately poor workability.	Slight	Moderate to severe: moderate to high shrink-swell potential.
Moderate to severe: moderate to high shrink-swell potential.	Slight: silt loam texture. Moderate: silty clay loam texture; moderately poor workability.	Slight	Moderate to severe: moderate to high shrink-swell potential.
Severe: very poorly drained; frequently ponded.	Severe: very poorly drained; frequently ponded.	Severe: very poorly drained; frequently ponded.	Severe: very poorly drained; frequently ponded.
Severe: high shrink-swell potential.	Moderate or severe: clay loam or silty clay texture.	Slight	Severe: high shrink-swell potential.
Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Slight	Severe: very rapid permeability in substratum; potential pollution hazard.	Severe: very rapid permeability in substratum; potential pollution hazard.	Slight.
Severe: very poorly drained	Severe: very poorly drained	Severe: very poorly drained	Severe: very poorly drained.
Severe: poorly drained	Severe: poorly drained; poor workability.	Severe: poorly drained	Severe: poorly drained; high shrink-swell potential.
Slight if slope is less than 9 percent, moderate if 9 to 15 percent, severe if more than 15 percent.	Severe: rapid permeability; potential pollution hazard.	Severe: rapid permeability; potential pollution hazard.	Slight if slope is 0 to 9 percent, moderate if 9 to 15 percent, severe if more than 15 percent.
Slight if slope is less than 9 percent, moderate if 9 to 15 percent, severe if more than 15 percent.	Severe: very rapid permeability; potential pollution hazard.	Severe: very rapid permeability; potential pollution hazard.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent, severe if more than 15 percent.
Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table; moderately rapid permeability in substratum.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Moderate: moderately well drained.	Slight	Slight	Moderate: moderate shrink-swell potential.
Moderate: moderately well drained; severe if substratum is silty clay.	Slight: loam or silt loam substratum. Moderate: silty clay loam or clay loam substratum. Severe: silty clay substratum.	Slight	Moderate to severe: moderate to high shrink-swell potential.
Severe: poorly drained; seasonal high water table.	Severe: moderately rapid permeability; potential pollution hazard.	Severe: poorly drained; moderately rapid permeability; potential pollution hazard.	Severe: poorly drained.
Severe: poorly drained; high shrink-swell potential in substratum.	Severe: poorly drained; poor workability in substratum.	Severe: poorly drained	Severe: poorly drained.
Severe: poorly drained; high potential frost action.	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Moderate to severe: moderate to high shrink-swell potential.	Moderate: clay loam substratum; moderately poor workability. Severe: silty clay substratum; poor workability.	Slight	Moderate to severe: moderate to high shrink-swell potential.
Severe: somewhat poorly drained.	Severe: rapid permeability; potential pollution hazard.	Severe: rapid permeability; potential pollution hazard.	Moderate: moderate potential frost action.

TABLE 7.—*Soil interpretations*

Soil series and map symbols	Degree and kind of limitation for—		
	Septic tank absorption fields	Sewage lagoons	Shallow excavations
Vallers: Va	Severe: moderately slow permeability; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained
Venlo: Ve	Severe: seasonal high water table; potential pollution hazard.	Severe: rapid permeability	Severe: seasonal high water table.
Wahpeton: Wa	Severe: moderately slow permeability.	Moderate: occasionally flooded.	Severe: clay texture
Wet alluvial land: We. Properties too variable to be rated.			
Wyndmere: Wy	Severe: seasonal high water table; potential pollution hazard.	Severe: moderately rapid permeability; seasonal high water table.	Severe: somewhat poorly drained.
*Zell: ZeD, ZeE. For Eckman part of ZeD and ZeE, see Eckman series.	Moderate if slope is less than 15 percent; severe if more than 15 percent.	Severe: slope	Moderate if slope is less than 15 percent, severe if more than 15 percent.

[1] Onsite study is needed of the deep underlying strata, the water table, and the hazards of aquifer pollution and drainage into

TABLE 8.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. carefully the instructions for referring to other

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Road fill	Sand or gravel	Topsoil	Pond reservoir areas
*Aastad: Af. For Forman part of Af, see Forman series.	Fair to poor: moderate or high shrink-swell potential.	Unsuitable	Good	Moderately slow permeability in substratum.
*Aberdeen: Ag, Ah, Ak, Ao. For Galchutt part of Ak, see Galchutt series; for Ryan part of Ao, see Ryan series.	Poor: high shrink-swell potential of substratum.	Unsuitable	Fair: less than 16 inches of suitable material.	Slow permeability of subsoil and substratum.
*Antler: Ar, As. For Tonka part of As, see Tonka series.	Fair to poor: moderate or high shrink-swell potential.	Unsuitable	Fair: silty clay loam texture; less than 16 inches of suitable material.	Moderately slow to slow permeability; seasonal high water table.
*Arveson: At, Au, Av. For Fossum part of At, Au, and Av, see Fossum series.	Poor: poorly drained and very poorly drained.	Poor for sand; excessive fines.	Poor: poorly drained and very poorly drained.	Seasonal high water table; moderately rapid permeability.
Arvilla: Aw	Good	Fair for sand; many fines.	Poor: shallow or moderately deep over gravel.	Very rapid permeability in substratum.
*Barnes: BbD, BbD2, BcD, BdB. For Buse part of BbD, BbD2, and BcD, see Buse series; for Langhei part of BcD, see Langhei series; for Svea part of BdB, see Svea series.	Fair: moderate shrink-swell potential.	Unsuitable	Good if slope is less than 8 percent, fair if 8 to 15 percent, poor if more than 15 percent.	Moderately slow permeability in substratum; slopes range from 3 to 20 percent.
*Bearden: Bf	Fair to poor: moderate or high shrink-swell potential.	Unsuitable	Good: silt loam texture. Fair: silty clay loam texture.	Moderately slow permeability; seasonal high water table.

for land-use planning—Continued

Degree and kind of limitation for—Continued			
Dwellings with basements	Sanitary landfill trench [1]	Sanitary landfill area	Local streets and roads
Severe: poorly drained.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained; seasonal high water table.	Severe: poorly drained.
Severe: seasonal high water table.	Severe: seasonal high water table; rapid permeability; potential pollution hazard.	Severe: seasonal high water table; rapid permeability; potential pollution hazard.	Severe: very poorly drained.
Severe: high shrink-swell potential; occasionally flooded.	Severe: occasionally flooded; poor workability.	Severe: occasionally flooded.	Severe: high shrink-swell potential.
Severe: somewhat poorly drained.	Severe: moderately rapid permeability; potential pollution hazard.	Severe: moderately rapid permeability; potential pollution hazard.	Severe: high potential frost action.
Moderate if slope is less than 15 percent, severe if more than 15 percent.	Slight if slope is less than 15 percent, moderate if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent.	Moderate if slope is less than 15 percent, severe if more than 15 percent.

ground water in landfill deeper than 5 or 6 feet.

interpretations of the soils

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow series that appear in the first column of this table]

Soil features affecting—Continued				
Embankments, dikes, levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed.	Moderately slow intake rate; high available water capacity; nearly level.	Short slopes.	All features favorable.
Medium to low shear strength; medium to low compressibility; slow permeability.	Claypan subsoil, slow permeability.	Slow permeability in subsoil and substratum.	Moderately coarse to fine-textured surface layer; fine-textured substratum, slow permeability.	Not needed.
Medium to low shear strength; medium compressibility; low permeability; fair to good compaction characteristics.	Seasonal high water table; moderately slow to slow permeability.	Moderately slow to slow permeability; seasonal high water table.	All features favorable.	Not needed.
Medium to high susceptibility to piping; low to medium compressibility; fair to good compaction characteristics.	Seasonal high water table; moderately rapid permeability.	Moderate available water capacity; seasonal high water table; needs drainage; moderately rapid intake.	Not needed.	Not needed.
Medium to high shear strength; low to medium compressibility; fair to good compaction characteristics.	Not needed.	Very rapid intake rate; low available water capacity.	Shallow and moderately deep to gravel; highly erodible; difficult to vegetate.	Shallow and moderately deep to gravel; low available water capacity; highly erodible; difficult to vegetate.
Medium to low shear strength; medium compressibility; high resistance to piping; fair to good compaction characteristics.	Not needed.	Moderately slow permeability in substratum; slopes range from 3 to 20 percent.	Short, irregular, undulating to steep slopes.	Slopes range from 3 to 20 percent; steeper slopes highly erodible.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal high water table; moderately slow permeability.	Moderately slow permeability; seasonal high water table.	Level soil; silt loam and silty clay loam texture; moderately slow permeability.	All features favorable.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Road fill	Sand or gravel	Topsoil	Pond reservoir areas
Bg. For Glyndon part of Bg, see Gt in Glyndon series.	Poor: high shrink-swell potential in substratum.	Unsuitable	Good	Slow permeability in substratum; seasonal high water table.
Bearden part of Overly-Bearden complex.	Fair or poor: moderate shrink-swell potential.	Unsuitable	Fair: moderate salinity.	Moderately slow permeability; seasonal high water table.
Beotia. Mapped only with Overly soils.	Fair: moderate shrink-swell potential.	Unsuitable	Fair: silty clay loam texture.	Moderate permeability
Borup: Bo, Br	Poor: poorly drained	Unsuitable	Poor: poorly drained	Moderately rapid permeability in substratum; seasonal high water table.
Buse. Mapped with Barnes, Forman, and Svea soils.	Fair: moderate shrink-swell potential; moderate potential frost action.	Unsuitable	Poor: less than 8 inches of suitable material.	Moderately slow permeability; slopes range from 3 to 20 percent.
Cashel: Ca	Poor: high shrink-swell potential.	Unsuitable	Poor: clay texture	Moderately slow permeability.
Colvin: Co	Poor: poorly drained	Unsuitable	Poor: poorly drained	Seasonal high water table; moderately slow permeability.
*Dickey: DkB. For Towner part of DkB, see Towner series.	Good to fair: moderate shrink-swell potential below a depth of 34 inches.	Unsuitable	Fair: less than 16 inches of suitable material.	Rapid permeability in upper part; moderately slow permeability in substratum.
*Doran: Do, Dp, Dt. For Perella part of Dp, see Perella series; for Tonka part of Dt, see Tonka series.	Poor: high potential frost action.	Unsuitable	Fair: clay loam and silty clay loam texture.	Moderately slow to slow permeability; nearly level slope.
Dovray: Dv	Poor: high shrink-swell potential.	Unsuitable	Poor: very poorly drained; clay texture.	Slow permeability; frequently ponded.
*Eckman: EeC. For Zell part of EeC, see Zell series.	Fair: ML material	Unsuitable	Good	Moderate: moderate permeability; slopes range from 3 to 20 percent.
*Egeland: EmB. For Maddock part of EmB, see Maddock series.	Good. Fair if ML material.	Unsuitable	Good	Moderately rapid permeability.
*Embden: En, Et. For Tiffany part of En and Et, see Td in Tiffany series.	Good or fair: fair if more than 30 percent fines.	Unsuitable	Good	Moderately rapid permeability.
Enloe. Mapped only with Fargo soils.	Poor: high shrink-swell potential.	Unsuitable	Poor: poorly drained	Slow permeability; frequently ponded.
*Exline: Ey. For Ryan part of Ey, see Ryan series.	Poor: high potential frost action.	Unsuitable	Poor: less than 8 inches of suitable material.	Very slow permeability

interpretations of the soils—Continued

Soil features affecting—Continued				
Embankments, dikes, levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Substratum has medium to low shear strength; high compressibility; fair to poor compaction characteristics, and poor workability.	Slow permeability in substratum; nearly level slopes; seasonal high water table.	Slow permeability in substratum; nearly level slope; seasonal high water table.	Nearly level soil; substratum has poor workability and slow permeability.	Nearly level soil; poor workability in substratum.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Moderately slow permeability; seasonal high water table.	Moderately slow intake rate; moderate salinity; seasonal high water table.	Nearly level soil; difficult to vegetate.	Nearly level soil; moderate salinity; difficult to vegetate.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	High available water capacity; moderate permeability; slopes range from 3 to 6 percent.	3 to 6 percent slopes; all soil features favorable.	All features favorable.
Medium to low shear strength; susceptible to piping; fair to good compaction characteristics.	Seasonal high water table; moderately rapid permeability in substratum.	Moderately rapid permeability in substratum; poorly drained.	Not needed	Not needed.
Medium to low shear strength; medium compressibility; low to medium susceptibility to piping; fair to good compaction characteristics.	Not needed	Moderately slow permeability; slopes range from 3 to 20 percent.	Short, irregular, undulating to steep slopes.	Slopes range from 3 to 20 percent; steeper slopes highly erodible.
Medium to low shear strength; high compressibility; high shrink-swell potential; fair to poor compaction characteristics.	Subject to flooding	Moderately slow permeability; subject to flooding.	Clayey materials; construction difficult.	Not needed.
Medium to low shear strength; medium compressibility; low permeability; fair to good compaction characteristics.	Seasonal high water table; moderately slow permeability; poorly drained.	Moderately slow permeability; seasonal high water table; poorly drained.	Not needed	Not needed.
Medium to low shear strength; upper part susceptible to piping; medium to low permeability in compacted soil.	Not needed	Susceptible to soil blowing; undulating slopes; moderately slow permeability in substratum.	Sandy surface layer; susceptible to soil blowing; 3 to 6 percent slopes.	Susceptible to accumulation from soil blowing.
Medium to high compressibility; low permeability; fair to good compaction characteristics.	Seasonal high water table; moderately slow to slow permeability.	Moderately slow to slow permeability; seasonal high water table.	Nearly level soil; moderately slow to slow permeability; clayey subsoil; construction difficult.	Not needed.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Frequently ponded; slow permeability.	Slow permeability; needs drainage.	Clay texture; slow permeability.	Not needed.
Medium to low shear strength; medium to low compressibility; high susceptibility to piping.	Not needed	Moderate permeability; high available water capacity; slopes range from 3 to 20 percent.	Slopes range from 3 to 20 percent; steeper slopes are highly erodible.	Slopes range from 3 to 20 percent; steeper slopes are highly erodible.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Not needed	Moderately rapid permeability; moderate available water capacity; slopes range from 3 to 6 percent.	Slopes range from 3 to 6 percent; susceptible to soil blowing; moderately rapid permeability.	Susceptible to soil blowing; moderate available water capacity.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Not needed	Moderately rapid permeability; high to moderate available water capacity; nearly level soil.	Nearly level soil; moderately susceptible to soil blowing; moderately rapid permeability.	Moderately susceptible to soil blowing; moderate available water capacity.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; frequently ponded.	Slow permeability; poorly drained.	Clay texture; slow permeability; construction difficult.	Not needed.
Medium to low shear strength; medium compressibility; low permeability; fair to good compaction characteristics.	Very slow permeability; shallow claypan; high content of sodium salts.	Very slow permeability; shallow claypan; high content of sodium salts.	Difficult to vegetate	Not needed.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Road fill	Sand or gravel	Topsoil	Pond reservoir areas
Fairdale: Fa, Fb, Fd	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Good	Moderate permeability
*Fargo: Fe, Ff, Fg, FhB, Fk, Fm, Fn, Fo, Fp, Fr, Fs. For Enloe part of Fm and Fn, see Enloe series; for Hegne part of Fo and Fp, see Hegne series; for Ryan part of Fr and Fs, see Ryan series.	Poor: high shrink-swell potential.	Unsuitable	Poor: fine textured; poorly drained.	Slow permeability; level soils; occasionally ponded.
*Fordville: Ft. For Renshaw part of Ft, see Renshaw series.	Good	Fair for gravel	Good: underlain by coarse sand and gravel.	Very rapid permeability in substratum.
*Forman: FuB, FuB2, FvC, FvC2, FwB. For Aastad part of FuB and FuB2, see Aastad series; for Buse part of FvC and FvC2, see Buse series; for Peever part of FwB, see Peever series.	Fair or poor: moderate or high shrink-swell potential.	Unsuitable	Good if texture is loam; fair if texture is clay loam.	Moderately slow permeability in substratum; slopes range from 0 to 9 percent.
Fossum: Fx	Poor: poorly drained	Unsuitable	Poor: poorly drained	Rapid permeability; seasonal high water table.
*Galchutt: Ga, Gc, Gd. For Enloe part of Gc, see Enloe series; for Fargo part of Gc, see Fargo series; for Overly part of Gd, see Od in Overly series.	Poor: high shrink-swell potential.	Unsuitable	Good if texture is silt loam; fair if texture is silty clay loam.	Slow permeability in substratum.
*Gardena: Ge, GfB, Gh. For Eckman part of GfB, see Eckman series; for Embden part of Gh, see Embden series.	Fair: ML material	Unsuitable	Good	Moderate permeability
*Gilby: Gk, Gn. For Hamerly part of Gn, see Hamerly series.	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Fair: less than 16 inches of suitable material.	Moderately slow permeability in substratum; seasonal high water table.
Gm	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Fair: moderate salinity.	Moderately slow permeability in substratum; seasonal high water table.
*Glyndon:				
Go, Gr, Gu. For Tiffany part of Gr, see Td in Tiffany series; for Wyndmere part of Gu, see Wyndmere series.	Fair: moderate potential frost action.	Unsuitable	Good	Moderate permeability
Gt. For Tiffany part of Gt, see Th in Tiffany series.	Fair: moderate potential frost action; substratum has high shrink-swell potential.	Unsuitable	Good	Slow permeability in substratum; seasonal high water table.
Grano: Gw	Poor: very poorly drained.	Unsuitable	Poor: very poorly drained; clay texture.	Slow permeability; seasonal high water table; frequently ponded.
*Hamar:				
Ha, Hc, Hf, Hg. For Ulen part of Hf and Hg, see Ulen series.	Fair or poor: poorly drained or somewhat poorly drained.	Unsuitable	Fair if somewhat poorly drained; poor if poorly drained.	Rapid permeability; seasonal high water table.
Hb, He	Poor: poorly drained; high shrink-swell potential in substratum.	Unsuitable	Poor: poorly drained	Slow permeability in substratum; seasonal high water table.

interpretations of the soils—Continued

Soil features affecting—Continued				
Embankments, dikes, levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Medium to low shear strength; medium compressibility; susceptible to piping.	Subject to flooding	Moderate permeability; high available water capacity; nearly level to channeled soil; subject to flooding.	Nearly level to channeled soil; subject to flooding.	Not needed.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; clay texture; poorly drained.	Slow permeability; level soil; poorly drained.	Clay texture; poor workability; slow permeability.	Not needed.
Medium to high shear strength; low to medium compressibility; fair to good compaction characteristics.	Not needed	Low available water capacity; very rapid permeability in substratum; slopes range from 0 to 6 percent.	Moderately deep over gravel; erodible; difficult to vegetate.	Moderately deep over gravel; low available water capacity; difficult to vegetate.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability in substratum; high available water capacity; slopes range from 0 to 9 percent.	Short, irregular, nearly level to rolling slopes.	Slopes range from 0 to 9 percent; all soil features favorable.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Rapid permeability; seasonal high water table.	Low to moderate available water capacity; seasonal high water table; needs drainage.	Not needed	Not needed.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability in substratum; seasonal high water table; level soil.	High available water capacity; slow permeability in substratum; seasonal high water table; level soil.	Clayey materials in substratum; slow permeability.	Not needed.
Medium to low shear strength; medium to low compressibility; high susceptibility to piping.	Not needed	Moderate permeability; high available water capacity; nearly level to gently undulating slopes.	Nearly level to gently undulating slopes; moderate permeability; cuts erodible unless vegetated.	All features favorable.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics in substratum.	Seasonal high water table; moderately slow permeability in substratum.	Moderately slow permeability in substratum; seasonal high water table.	Nearly level slopes; moderately slow permeability in substratum; upper part erodible.	Not needed.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics in substratum.	Seasonal high water table; moderately slow permeability in substratum.	Moderately slow permeability in substratum; moderate salinity.	Nearly level slopes; moderate salinity; difficult to vegetate.	Not needed.
Medium to low shear strength; medium compressibility; high susceptibility to piping.	Somewhat poorly drained; moderate permeability.	Moderate permeability; nearly level slopes; seasonal high water table.	Nearly level slopes; moderate permeability; cuts erodible unless vegetated.	All soil features favorable.
Substratum has low to medium shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability in substratum; nearly level slopes; seasonal high water table.	Slow permeability in substratum; nearly level slopes; seasonal high water table.	Nearly level slopes; substratum has poor workability and slow permeability.	Level soil; poor workability in substratum.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability, frequently ponded; nearly level slopes.	Slow permeability; needs drainage.	Nearly level slopes; slow permeability; clay texture; poor workability.	Not needed.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Rapid permeability; seasonal high water table; level soil.	Rapid permeability; low to moderate available water capacity; needs drainage.	Not needed	Not needed.
Medium to low shear strength; upper part has medium to high susceptibility to piping; substratum has fair to poor compaction characteristics.	Slow permeability in substratum; seasonal high water table; level soil; poorly drained.	Slow permeability in substratum; poorly drained; seasonal high water table.	Not needed	Not needed.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Road fill	Sand or gravel	Topsoil	Pond reservoir areas
Hamerly: Hh	Fair: moderate potential frost action.	Unsuitable	Fair: less than 16 inches of suitable material.	Moderately slow permeability in substratum; seasonal high water table.
*Hecla:				
Hm, Hm3, Hn, Ho, Hr, Hs. For Hamar part of Hm, Hm3, Hn and Ho, see Ha in Hamar series; for Arveson part of Ho, see Arveson series; for Maddock part of Hr and Hs, see Maddock series.	Good or fair: fair if more than 30 percent fines.	Unsuitable	Good: fine sandy loam texture. Poor: loamy fine sand texture.	Rapid permeability
Hk	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Good: fine sandy loam texture. Poor: loamy fine sand texture.	Rapid permeability to a depth of 36 inches; moderately slow below.
Hegne. Mapped only with Fargo soils.	Poor: high shrink-swell potential.	Unsuitable	Poor: fine textured; poorly drained.	Slow permeability; level slopes; seasonal high water table.
Kratka: Kr	Poor: poorly drained	Unsuitable	Poor: poorly drained	Moderately slow permeability in substratum; seasonal high water table.
*LaDelle: La, Lb. For Wahpeton part of Lb, see Wahpeton series.	Fair: moderate shrink-swell potential.	Unsuitable	Fair: silty clay loam texture.	Moderate permeability; nearly level to channeled slopes.
Lamoure: Lm	Poor: high shrink-swell potential; high potential frost action.	Unsuitable	Poor: poorly drained	Moderate permeability; seasonal high water table; nearly level slopes.
Langhei. Mapped only with Barnes and Buse soils.	Fair: moderate shrink-swell potential.	Unsuitable	Poor: less than 8 inches of suitable material.	Moderately slow permeability; slopes range from 12 to 20 percent.
LaPrairie: Lp	Fair: moderate potential frost action.	Unsuitable	Good	Moderate permeability; nearly level slopes.
*Maddock: MdC, MhB, MlB. For Hecla part of MhB and MlB, see Hecla series; for Hamar part of MlB, see Ha in Hamar series.	Good	Poor: excessive fines.	Good: sandy loam or fine texture. Poor: loamy sand or loamy fine sand texture.	Rapid permeability
Marsh: Mr. Properties too variable to be rated.				
Nutley: NuC	Poor: high shrink-swell potential.	Unsuitable	Poor: clay texture	Slow permeability; slopes range from 6 to 9 percent.
*Overly:				
Oc, OlB. For Beotia part of OlB, see Beotia series.	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Good: silt loam texture. Fair: silty clay loam texture.	Moderately slow permeability.
Od, Oe. For Bearden part of Od and Oe, see Bearden series.	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Fair: moderate salinity.	Moderately slow permeability.
*Parnell: Pc, Pd. For Tonka part of Pd, see Tonka series.	Poor: very poorly drained.	Unsuitable	Poor: very poorly drained.	Frequently ponded; slow permeability.

interpretations of the soils—Continued

Soil features affecting—Continued				
Embankments, dikes, levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Moderately slow permeability in substratum; seasonal high water table; nearly level slopes.	Nearly level slopes; moderately slow permeability in substratum; high available water capacity.	Nearly level slopes; moderately slow permeability in substratum; outlets generally not available.	Nearly level slopes; all soil features favorable.
Medium shear strength; medium to low permeability of compacted soil; medium to high susceptibility to piping.	Not needed	Rapid permeability; low to moderate available water capacity; nearly level slopes; susceptible to soil blowing.	Nearly level slopes; susceptible to soil blowing.	Susceptible to soil blowing; high potential for windblown accumulations.
Medium to low shear strength; fair to good compaction characteristics; upper part has medium to high susceptibility to piping.	Not needed	Moderately slow permeability in substratum; moderate available water capacity.	Nearly level slopes; susceptible to soil blowing.	Susceptible to soil blowing; high potential for windblown accumulations.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; level slopes; fine texture.	Slow permeability; level slopes; high available water capacity.	Level slopes; clay materials; poor workability; slow permeability.	Not needed.
Medium to low shear strength; upper part has high susceptibility to piping; fair to good compaction characteristics in substratum.	Moderately slow permeability in substratum; seasonal high water table.	Level slopes; moderately slow permeability in substratum; seasonal high water table.	Not needed	Not needed.
Medium to low shear strength; medium compressibility; low permeability of compacted soils; fair to good compaction characteristics.	Not needed	High available water capacity; nearly level to channeled slopes; moderate permeability.	Not needed	Not needed.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Moderate permeability; seasonal high water table; subject to flooding.	Moderate permeability; frequently flooded; seasonal high water table.	Not needed	Not needed.
Medium to low shear strength; medium compressibility; low to medium susceptibility to piping; fair to good compaction characteristics.	Not needed	Moderately slow permeability; slopes range from 12 to 20 percent.	Short, irregular, steep slopes.	Steep slopes; highly erodible.
Medium to low shear strength; medium compressibility; medium to high susceptibility to piping.	Not needed	High available water capacity; nearly level slopes; moderate permeability.	Not needed	Not needed.
Medium shear strength; medium to low permeability of compacted soil; medium to high susceptibility to piping.	Not needed	Rapid permeability; low available water capacity; slopes range from 3 to 9 percent; susceptibility to soil blowing.	Slopes range from 3 to 9 percent; susceptible to soil blowing.	Susceptible to soil blowing; high potential for windblown accumulations.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Not needed	Slow permeability; slopes range from 6 to 9 percent.	Slopes range from 6 to 9 percent; clay texture; poor workability.	Slopes range from 6 to 9 percent; clay texture; poor workability; difficult to vegetate.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability; high available water capacity; slopes range from 0 to 6 percent.	Smooth slopes ranging from 0 to 6 percent; other soil features favorable.	All features favorable.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability; moderate salinity.	Nearly level slopes; moderate salinity; difficult to vegetate.	Nearly level slopes; moderate salinity; difficult to vegetate.
Medium to low shear strength; medium to high compressibility; low permeability of compacted soil.	Frequently ponded; outlets usually not available.	Slow permeability; very poorly drained.	Not needed	Not needed.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Road fill	Sand or gravel	Topsoil	Pond reservoir areas
Peat: Pe. Properties too variable to be rated.				
*Peever: Pf. For Forman part of Pf, see Forman series.	Poor: high shrink-swell potential.	Unsuitable	Poor: less than 8 inches of suitable material.	Slow to moderately slow permeability; slopes range from 0 to 6 percent.
Perella: Pr, Ps	Poor: poorly drained	Unsuitable	Poor: poorly drained	Moderately slow to slow permeability; frequently ponded; seasonal high water table.
Renshaw. Mapped only with Fordville and Sioux soils.	Good	Fair for gravel; exeessive fines.	Poor: shallow depth over gravel.	Very rapid permeability in substratum.
Roliss: Ro	Poor: very poorly drained.	Unsuitable	Poor: very poorly drained.	Frequently ponded; moderately slow permeability; seasonal high water table.
*Ryan: Ry. For Fargo part of Ry, see Fargo series.	Poor: high shrink-swell potential.	Unsuitable	Poor: less than 8 inches of suitable material.	Very slow permeability; nearly level slopes.
Serden: Sd, Se. Stabilized dune land part of Se is too variable to be rated.	Good if slope is less than 15 percent, fair if more than 15 percent.	Unsuitable	Poor: sandy texture	Rapid permeability
*Sioux: ShB, ShE. For Renshaw part of ShB and ShE, see Renshaw series.	Good if slope is less than 15 percent, fair if more than 15 percent.	Good or fair depending on content of fines.	Poor: shallow depth over gravel.	Very rapid permeability
Stabilized dune land. Mapped only with Searden soils. Properties too variable to be rated.				
*Stirum: Sr. For Arveson part of Sr, see Arveson series.	Poor: poorly drained	Fair for sand; fines.	Poor: poorly drained	Moderately rapid permeability in substratum; seasonal high water table.
Strongly saline land: St. Properties too variable to be rated.				
*Svea: Su, SvB, SvC, Sw. For Buse part of SvB and SvC, see Buse series; for Gardena part of Sw, see Gardena series.	Fair: moderate shrink-swell potential.	Unsuitable	Good	Moderately slow permeability in substratum; slopes range from 0 to 9 percent.
*Swenoda: Sy. For Wyndmere part of Sy, see Wyndmere series.	Fair to poor: moderate to high shrink-swell potential.	Unsuitable	Good	Moderately slow to slow permeability in substratum; high seepage potential in upper part.
Tiffany: Td, Tf	Poor: poorly drained	Unsuitable	Poor: poorly drained	Seasonal high water table; moderately rapid permeability.
Th	Poor: poorly drained	Unsuitable	Poor: poorly drained	Seasonal high water table; slow permeability in substratum.
Tonka: Tk	Poor: poorly drained	Unsuitable	Poor: poorly drained	Slow permeability; frequently ponded.

interpretations of the soils—Continued

Soil features affecting—Continued				
Embankments, dikes, levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Medium to low shear strength; medium to high compressibility; fair to good compaction characteristics.	Not needed	Slow to moderately slow permeability; high available water capacity; slopes range from 0 to 6 percent.	Slopes range from 0 to 6 percent; clayey textures; slow to moderately slow permeability.	Clayey texture; high available water capacity; slopes range from 0 to 6 percent.
Medium to low shear strength; medium to high compressibility; low permeability of compacted soil.	Moderately slow to slow permeability; frequently ponded.	Slow permeability in substratum; high available water capacity; needs drainage.	Level soil; slow permeability in substratum.	Not needed.
Medium to high shear strength; low to medium compressibility; fair to good compaction characteristics.	Not needed	Low available water capacity; very rapid permeability in substratum; slopes range from 0 to 6 percent.	Slopes range from 0 to 6 percent; shallow to gravel; erodible; difficult to vegetate.	Shallow depth over gravel; low available water capacity; difficult to vegetate.
Medium to low shear strength; medium to high compressibility; low permeability of compacted soil.	Frequently ponded; seasonal high water table; outlets usually not available.	Frequently ponded; seasonal high water table; needs drainage; moderately slow permeability.	Not needed	Not needed.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Very slow permeability; level slopes; occasionally ponded.	Very slow permeability; salts in substratum; level slopes.	Clay texture; level soil; poor workability; very slow permeability; difficult to vegetate.	Not needed.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Not needed	Low available water capacity; rapid permeability; slopes range from 3 to 20 percent.	Slopes range from 3 to 20 percent; highly susceptible to soil blowing.	Not needed.
Medium to high shear strength; low to medium compressibility; medium to high permeability of compacted soil.	Not needed	Very low available water capacity; very rapid permeability.	Slopes range from 0 to 25 percent; shallow depth over gravel; difficult to vegetate; very erodible.	Not needed.
Medium to low shear strength; low to medium compressibility; medium to high susceptibility to piping.	Seasonal high water table; sodium salts in subsoil; moderately rapid permeability in substratum.	Moderate slow permeability; seasonal high water table; sodium salts in subsoil.	Level soil; substratum highly erodible; sodium salts in subsoil; difficult to vegetate.	Not needed.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability in substratum; high available water capacity; slopes range from 0 to 9 percent.	Slopes range from 0 to 9 percent; other soil features favorable.	All features favorable.
Substratum has low to medium shear strength; medium to high compressibility; low permeability of compacted soil.	Not needed	Moderately slow to slow permeability in substratum; high available water capacity.	Nearly level slopes; upper part susceptible to soil blowing.	Not needed.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Moderately rapid permeability; seasonal high water table.	Moderate to high available water capacity; moderately rapid permeability; needs drainage.	Level soil; susceptible to soil blowing.	Not needed.
Substratum has medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability in substratum; seasonal high water table.	Slow permeability in substratum; poorly drained.	Level soil; substratum has clay texture and slow permeability.	Not needed.
Medium to low shear strength; medium to high compressibility; slow permeability of compacted soil.	Frequently ponded; outlets usually not available.	Slow permeability; subject to ponding.	Not needed	Not needed.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—
	Road fill	Sand or gravel	Topsoil	Pond reservoir areas
*Towner: To, Tw. For Swenoda part of Tw, see Swenoda series.	Good to poor: moderate to high shrink-swell potential.	Unsuitable	Good if fine sandy loam; poor if loamy fine sand.	Moderately slow permeability in substratum; high seepage potential.
Ulen: Un	Fair: moderate potential frost action.	Unsuitable	Good if fine sandy loam; poor if loamy fine sand.	Rapid permeability; seasonal high water table.
Vallers: Va	Poor: poorly drained	Unsuitable	Poor: poorly drained	Moderately slow permeability; seasonal high water table.
Venlo: Ve	Poor: very poorly drained.	Unsuitable	Poor: very poorly drained.	Seasonal high water table; rapid permeability.
Wahpeton: Wa	Poor: high shrink-swell potential.	Unsuitable	Poor: clay texture	Moderately slow permeability.
Wet alluvial land: We. Properties too variable to be rated.				
Wyndmere: Wy	Poor: high potential frost action.	Unsuitable	Good	Moderately rapid permeability; seasonal high water table.
*Zell: ZeD, ZeE. For Eckman part of ZeD and ZeE, see Eckman series.	Fair: ML material with plasticity of less than 15.	Unsuitable	Poor: less than 8 inches of suitable material.	Moderate permeability; slopes range from 9 to 20 percent.

TABLE 9.—*Engineering*

[Tests performed by North Dakota State University in cooperation with North Dakota State Highway

Soil and location	Parent material	North Dakota report number	Depth from surface	Moisture density [1]		Mechanical analysis [2]			
						Percentage passing sieve—			
				Maximum dry density	Optimum moisture	1 inch	¾ inch	⅜ inch	No. 4 (4.7 mm)
		SCS–	*Inches*	*Pounds per cubic foot*	*Percent*				
Embden fine sandy loam: 95 feet east and 0.25 mile south of northwest corner of sec. 3, T. 133 N., R. 49 W. (Modal.)	Moderately coarse textured lacustrine sediments.	142	7–14	103	15	—	—	—	—
		143	19–33	108	14	—	—	—	—
		144	39–60	101	16	—	—	—	—
2,415 feet north and 125 feet east of southwest corner of sec. 30, T. 133 N., R. 50 W. (Substratum siltier than modal.)		179	8–20	106	17	—	—	—	—
		180	20–31	108	15	—	—	—	—
		181	40–60	108	15	—	—	—	—
2, 420 feet south and 464 feet east of northwest corner of sec. 33, T. 134 N., R. 50 W. (Substratum sandier than modal.)		145	9–18	106	15	—	—	—	—
		146	30–46	101	18	—	—	—	—
		147	46–60	96	19	—	—	—	—

interpretations of the soils—Continued

Soil features affecting—Continued				
Embankments, dikes, levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Medium to low shear strength; fair to good compaction characteristics; upper part has medium to high susceptibility to piping.	Not needed	Moderately slow permeability in substratum; moderate or high available water capacity; susceptible to soil blowing.	Nearly level slopes; susceptible to soil blowing.	Susceptible to soil blowing.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Seasonal high water table; nearly level slopes; rapid permeability.	Rapid permeability; low to moderate available water capacity; seasonal high water table.	Nearly level slopes; highly susceptible to soil blowing.	Highly susceptible to soil blowing; high potential for windblown accumulations.
Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal high water table; outlets usually not available.	Moderately slow permeability; seasonal high water table; needs drainage.	Nearly level slopes; moderately slow permeability; outlets usually not available.	Not needed.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Seasonal high water table; rapid permeability.	Rapid permeability; very poorly drained.	Not needed	Not needed.
Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Not needed	Moderately slow permeability; high available water capacity; nearly level slopes; occasionally flooded.	Not needed	Not needed.
Medium shear strength; low to medium compressibility; medium to high susceptibility to piping.	Seasonal high water table; moderately rapid permeability.	Moderately rapid permeability; high to moderate available water capacity; seasonal high water table.	Nearly level slopes; susceptible to soil blowing.	Nearly level slopes; subject to windblown accumulations.
Medium to low shear strength; medium to low compressibility; high susceptibility to piping.	Not needed	Moderate permeability; high available water capacity; slopes range from 9 to 20 percent.	Slopes range from 9 to 20 percent; highly erodible.	Slopes range from 9 to 20 percent; highly erodible.

test data

Department in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]—Continued											
Percentage passing sieve—Continued				Percentage smaller than—				Liquid limit	Plasticity index	Classification	
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 60 (0.25 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			AASHO [3]	Unified [4]
								Percent			
—	100	99	25	19	11	7	4	[5] NP	NP	A-2-4(0)	SM
—	—	100	32	24	15	12	9	NP	NP	A-2-4(0)	SM
—	100	99	36	23	10	7	5	NP	NP	A-4(0)	SM
—	100	99	32	24	12	6	4	NP	NP	A-2-4(0)	SM
—	—	100	32	23	13	10	8	NP	NP	A-2-4(0)	SM
—	—	100	60	42	17	12	10	NP	NP	A-4(5)	ML
—	—	100	24	18	11	9	8	NP	NP	A-2-4(0)	SM
—	—	100	28	18	8	7	5	NP	NP	A-2-4(0)	SM
—	—	100	18	11	5	3	3	NP	NP	A-2-4(0)	SM

TABLE 9.—*Engineering*

Soil and location	Parent material	North Dakota report number	Depth from surface	Moisture density [1]: Maximum dry density	Moisture density [1]: Optimum moisture	Mechanical analysis [2] — Percentage passing sieve—: 1 inch	¾ inch	⅜ inch	No. 4 (4.7 mm)
		SCS-	*Inches*	*Pounds per cubic foot*	*Percent*				
Fargo silty clay: 165 feet west and 1,925 feet north of southwest corner of sec. 18, T. 135 N., R. 48 W. (Modal.)	Fine textured lacustrine sediments.	185	9–13	87	27	—	—	—	—
		186	35–45	98	23	—	—	—	—
62 feet south and 505 feet west of center of sec. 7, T. 135 N., R. 48 W. (Surface layer thinner than modal.)		163	7–14	95	26	—	—	—	—
		164	14–29	94	23	—	—	—	—
		165	29–42	99	26	—	—	—	—
3,218 feet east and 2,432 feet north of southwest corner of sec. 8, T. 135 N., R. 48 W. (Thicker surface layer than modal.)		166	11–23	95	23	—	—	—	—
		167	23–36	95	23	—	—	—	—
		168	36–48	95	24	—	—	—	—
95 feet east and 125 feet north of southwest corner of sec. 8, T. 135 N., R. 48 W. (Depressional.)		161	10–28	96	23	—	—	—	—
		162	28–50	95	23	—	—	—	—
Forman loam: 1,120 feet east and 200 feet south of northwest corner of sec. 20, T. 129 N., R. 52 W. (Modal.)	Glacial till.	130	7–18	99	22	—	—	100	99
		131	18–36	102	20	—	—	—	100
		133	36–60	100	22	—	—	—	100
95 feet south and 2,525 feet east of northwest corner of sec. 3, T. 129 N., R. 50 W. (Loam substratum.)		182	7–15	98	21	—	—	—	100
		183	15–32	101	22	—	—	100	99
		184	32–60	109	18	100	98	96	94
310 feet west and 15 feet north of southeast corner of sec. 18, T. 130 N., R. 51 W. (Weaker B horizon than modal.)		132	7–13	109	16	—	100	99	99
		134	13–36	110	18	—	100	99	98
Galchutt silt loam: 110 feet north and 200 feet east of center of sec. 6, T. 132 N., R. 49 W. (Modal.)	Silty lacustrine sediments and underlying clayey lacustrine sediments.	138	8–19	109	16	—	—	—	—
		139	25–50	92	27	—	—	—	100
Gardena loam: 200 feet west and 1,215 feet north of southeast corner of sec. 13, T. 132 N., R. 52 W. (Modal.)	Medium-textured lacustrine sediments.	169	0–7	109	14	—	—	—	—
		170	7–16	110	15	—	—	—	—
		171	20–28	106	19	—	—	—	—
		172	28–60	105	18	—	—	—	100
2,484 feet north and 679 feet east of southwest corner of sec. 9, T. 132 N., R. 50 W. (Coarser textured than modal.)		140	11–20	108	15	—	—	—	—
		141	33–52	103	16	—	—	—	—
Glyndon silt loam: 925 feet west and 2,500 feet north of the southeast corner of sec. 11, T. 132 N., R. 51 W. (Modal.)	Medium-textured lacustrine sediments.	135	0–8	96	20	—	—	—	—
		136	8–18	109	17	—	—	—	—
		137	22–42	112	15	—	—	—	—
340 feet west and 2,256 feet south of northeast corner of sec. 2, T. 133 N., R. 49 W. (Moderately deep over clay.)	Medium-textured lacustrine sediments underlain by clay.	148	14–28	110	16	—	—	—	—
		149	28–40	107	15	—	—	—	—
		150	40–60	94	26	—	—	—	—

test data—Continued

Mechanical analysis [2]—Continued										Classification	
Percentage passing sieve—Continued				Percentage smaller than—				Liquid limit	Plasticity index		
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 60 (0.25 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			AASHO [3]	Unified [4]
								Percent			
100	99	98	90	82	68	44	32	53	20	A-7-5(15)	MH
—	100	99	97	93	86	73	66	65	37	A-7-6(20)	CH
100	99	97	91	87	79	66	53	62	29	A-7-5(20)	MH or CH
100	99	98	95	92	84	71	61	58	34	A-7-6(20)	CH
—	—	100	98	95	90	75	71	64	35	A-7-6(20)	MH or CH
—	100	99	95	83	64	54	44	48	20	A-7-6(14)	ML or CL
—	100	99	98	93	83	75	62	60	33	A-7-6(20)	CH
—	—	100	99	97	92	83	76	64	41	A-7-6(20)	CH
100	99	99	97	93	85	73	61	66	36	A-7-5(20)	MH or CH
100	99	99	98	95	89	80	72	69	39	A-7-5(20)	CH
98	93	88	76	69	53	37	29	44	22	A-7-6(14)	CL
99	97	96	91	86	75	53	36	43	20	A-7-6(13)	CL
99	98	97	93	90	81	55	37	42	16	A-7-6(11)	ML or CL
99	93	86	74	67	53	37	29	43	17	A-7-6(14)	ML or CL
98	93	90	80	75	65	45	31	43	19	A-7-6(12)	CL
89	79	75	61	56	45	27	18	35	12	A-6(6)	ML or CL
97	92	89	74	61	38	24	19	35	12	A-6(9)	ML or CL
95	90	86	77	72	61	44	30	38	15	A-6(10)	CL
—	—	100	63	45	26	20	17	NP	NP	A-4(6)	ML
99	99	98	96	92	84	78	77	61	32	A-7-6(20)	CH or MH
100	99	98	45	34	20	14	10	NP	NP	A-4(2)	SM
100	99	98	54	44	26	16	12	NP	NP	A-4(4)	ML
100	99	99	90	78	54	27	17	31	7	A-4(8)	ML
99	99	99	96	85	58	28	19	31	6	A-4(8)	ML
—	—	100	46	31	17	13	11	NP	NP	A-4(2)	SM
—	—	100	59	34	11	9	8	NP	NP	A-5(5)	ML
100	99	99	71	56	33	22	17	37	11	A-6(8)	ML
100	98	97	72	61	39	26	21	35	14	A-6(9)	CL
—	—	100	89	68	34	19	15	NP	NP	A-4(8)	ML
—	—	100	61	44	26	21	18	NP	NP	A-4(5)	ML
—	—	100	65	43	79	16	14	NP	NP	A-4(6)	ML
—	—	100	99	95	88	76	67	61	35	A-7-6(20)	CH

TABLE 9.—*Engineering*

Soil and location	Parent material	North Dakota report number	Depth from surface	Moisture density[1]: Maximum dry density	Moisture density[1]: Optimum moisture	Mechanical analysis[2] — Percentage passing sieve—: 1 inch	¾ inch	⅜ inch	No. 4 (4.7 mm)
		SCS–	*Inches*	*Pounds per cubic foot*	*Percent*				
Glyndon loam: 430 feet north and 110 feet east of southwest corner of sec. 13, T. 134 N., R. 52 W. (Sandier substrata than modal.)	Medium-textured and moderately coarse textured lacustrine sediments.	176	7–16	111	16	—	—	—	—
		177	16–23	117	13	—	—	—	—
		178	38–60	97	18	—	—	—	—
1,477 feet north and 197 feet east of southwest corner of sec. 5, T. 133 N., R. 51 W. (Slightly sodic substrata.)		155	16–25	112	15	—	—	—	—
		156	31–46	119	14	—	—	—	100
		157	46–60	108	16	—	—	—	—
Hecla loamy fine sand: 120 feet east and 335 feet north of southwest corner of sec. 31, T. 136 N., R. 50 W. (Modal.)	Lacustrine sands.	173	7–15	109	14	—	—	—	—
		174	15–24	106	14	—	—	—	—
		175	38–60	102	15	—	—	—	—
85 feet south and 1,990 feet west of northeast corner of sec. 7, T. 133 N., R. 51 W. (Thinner surface layer than modal.)	Lacustrine and eolian sands.	151	0–12	104	16	—	—	—	—
		152	30–53	102	13	—	—	—	—
Hecla loamy sand: 1,635 feet south and 173 feet east of the northwest corner of sec. 3, T. 134 N., R. 54 W. (Coarser textured than modal.)	Lacustrine and eolian sands.	127	8–17	117	12	—	—	—	—
		128	17–35	114	12	—	—	—	—
		129	56–60	116	12	—	—	—	—
Stirum loam: 83 feet north and 855 feet east of southwest corner of sec. 10, T. 134 N., R. 52 W. (Modal.)	Moderately coarse textured lacustrine sediments.	158	7–27	121	12	—	—	—	—
		159	30–46	105	15	—	—	—	—
		160	46–60	102	17	—	—	—	—

[1] Based on AASHO Designation T 99–57, Methods A and C (*1*).
[2] Mechanical analyses according to the AASHO Designation T 88. Results by this procedure frequently differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method

Soil properties significant in engineering

Estimates of soil properties significant in engineering are shown in table 6. These estimates are made for representative soil profiles by layers that have significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 6.

Depth to the seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years. Depth to bedrock is not given because it is more than 5 feet in most soils of the survey area.

Soil texture is described in the standard terms used by the Department of Agriculture. These terms are based on the percentages of sand, silt, and clay in the less than 2 millimeter fraction of the soil. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt, "clay," and some of the other terms used in USDA textural classification are defined in the Glossary.

Liquid limit and plasticity index are water contents obtained by specified tests. As the water content of a clayey soil, from which the particles coarser than 0.42 millimeter have been removed, is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further in-

test data—Continued

Mechanical analysis [2]—Continued								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued				Percentage smaller than—						AASHO [3]	Unified [4]
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 60 (0.25 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
								Percent			
—	100	95	33	28	21	16	13	NP	NP	A-2-4(0)	SM
—	100	95	37	33	25	20	16	NP	NP	A-4(0)	SM
—	100	97	9	6	3	2	2	NP	NP	A-3(0)	SP-SM
—	100	99	45	33	19	16	14	NP	NP	A-4(2)	SM
98	96	96	71	55	38	29	21	25	8	A-4(7)	CL
—	100	99	50	34	15	12	10	NP	NP	A-4(3)	SM
—	100	99	17	15	12	10	8	NP	NP	A-2-4(0)	SM
—	—	100	14	12	10	9	7	NP	NP	A-2-4(0)	SM
—	—	100	13	10	7	5	4	NP	NP	A-2-4(0)	SM
—	100	98	15	10	6	4	3	NP	NP	A-2-4(0)	SM
—	100	98	8	6	4	4	4	NP	NP	A-3(0)	SP-SM
100	96	68	19	16	12	6	4	NP	NP	A-2-4(0)	SM
100	96	69	18	14	10	8	6	NP	NP	A-2-4(0)	SM
100	99	75	19	16	13	11	8	NP	NP	A-2-4(0)	SM
—	100	99	54	45	33	28	27	NP	NP	A-4(4)	ML
—	—	100	47	30	12	8	7	NP	NP	A-4(2)	SM
—	100	99	13	9	5	4	4	NP	NP	A-2-4(0)	SM

and material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes of soils.

[3] Based on AASHO Designation M 145-49.

[4] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. An example is SP-SM.

[5] Nonplastic.

creased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of water content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 6. In table 9 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability, as used in this survey, is an estimate of the rate at which saturated soil transmits water downward under a unit head of pressure. Estimates are based on those soil characteristics observed in the field, particularly structure, porosity, and texture. Lateral seepage or such transient soil features as plowpans and surface crusts are not considered.

Available water capacity is an estimate of the capacity of the soils to hold water for use by most plants. It is defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants.

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils can damage building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in,

on, or with such material. Shrink swell is not rated for organic soils or certain soils that shrink markedly on drying but do not swell quickly when rewetted.

Corrosivity, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens steel or concrete. The rate of corrosion of steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. A corrosivity rating of *low* indicates a low probability of soil-induced corrosion damage. A rating of *high* indicates a high probability of damage, so that protective measures for steel and more resistant concrete are needed to reduce damage.

Engineering interpretations

The estimated interpretations in tables 7 and 8 are based on the engineering properties of soils shown in table 6, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of the survey area. In tables 7 and 8 ratings summarize the limitation or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, ponds and reservoirs, embankments, terraces and diversions, and grassed waterways. For these particular uses, table 7 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight, moderate,* and *severe* and *very severe. Slight* means soil properties generally favorable for the rated use, or in other words, limitations that are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required. *Very severe* means one or more soil properties so unfavorable for a particular use that overcoming the limitations is most difficult and costly and commonly not practical for the rated use.

Dwellings with basements are no more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties to be considered are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated the ratings in table 7 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet. Onsite investigation is needed before a site is selected.

Local roads and streets have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and the amount of cut and fill needed to reach an even grade.

Following are explanations of columns in table 8.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and (2) the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, nor do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response to fertilization; and absence of substances toxic to plants. Texture of the soil material and the content of stone fragments are highly significant. Also considered is the damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among factors that are unfavorable.

Drainage of crops and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage or depth to water table or bedrock.

Terraces and diversions are embankments or ridges constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable materials; stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Grassed waterways are natural or constructed, typically broad and shallow waterways that carry runoff. They are planted to grass as protection against erosion.

Soil test data

Table 9 contains engineering test data for some of the major soil series in Richland County and the Sheyenne National Grassland Area of Ransom County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material as has been explained for table 6.

Formation and Classification of the Soils

This section describes the major factors of soil formation and tells how these factors have affected the soils in Richland County and the Sheyenne National Grassland Area of Ransom County. It also defines the system of soil classification currently used and shows how the soils of the county have been classified according to the current system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineral composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a soil that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation for soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The soils in the survey area formed in glacial lacustrine sediments, glacial till, alluvium, and eolian sands. Variations in texture, uniformity of particle size, and mineral and chemical composition among these parent materials have had a strong modifying effect on the characteristics of the soils in the survey area. These effects are reflected mainly in such soil properties as texture, permeability, available water capacity, shrink-swell potential, and the formation of sodic claypans.

During Pleistocene time the survey area was covered by the Mankato substage of the Late Wisconsin Glaciation and several earlier glacial ice sheets (*2*). A mantle of glacial drift, 154 to 490 feet thick, including the deposits in glacial Lake Agassiz, covered the bedrock formations. As the last ice sheet retreated to the north, glacial Lake Agassiz was formed and covered all of the survey area except the extreme southwestern part of Richland County. At its maximum, glacial Lake Agassiz extended more than 550 miles from northeastern South Dakota through eastern North Dakota and western Minnesota to northern Manitoba, and it had an average width of about 15 miles (*2*). The sediments deposited in Lake Agassiz make up the parent materials of the soils in more than 80 percent of the survey area.

Glacial lacustrine sediments in the survey area range from sand to clay. The preglacial Sheyenne River flowed into glacial Lake Agassiz from the west carrying a

heavy load of glacial outwash from the melting ice front. The coarser textured sediments were deposited at the mouth of the river near the western shoreline of Lake Agassiz and formed the Sheyenne Delta. The finer textured sediments were carried farther out toward the center of the lake. In some places sandy or silty sediments were deposited over clayey sediments. This type of stratification resulted in the formation of soils that have two-storied profiles, such as the Galchutt, Towner, and Swenoda soils.

The soils that formed in lacustrine sediments differ mainly on the basis of characteristics resulting from the wide range in the texture of the sediments. Some soils have profile characteristics that are directly attributable to a high level of sodium in the parent material. The differences resulting from texture of the parent material are reflected most strikingly if soils formed in coarse-textured sediments are contrasted with those formed in fine-textured sediments. Hecla and Maddock soils, for example, which formed in loamy sands, have low or moderate available water capacity, rapid permeability, moderate or low natural fertility, and low shrink-swell potential. Conversely, the Fargo soils, which formed in lacustrine clays, have high available water capacity, slow permeability, high natural fertility, and high shrink-swell potential. They shrink and crack when dry and swell when wet because they have a high content of montmorillonitic clay. Between these two extremes are soils that formed in moderately coarse textured to moderately fine textured sediments, as represented by the Embden, Gardena, and Overly soils. These soils have moderately rapid to moderately slow permeability, moderate to high available water capacity, high natural fertility, and low to moderate shrink-swell potential.

The soils that formed in lacustrine sediments containing a high level of sodium, as represented by the Aberdeen, Exline, Ryan, and Stirum soils, are characterized by a dense, sodic claypan subsoil near the surface.

Glacial till in the survey area consists of calcareous loam and clay loam of mixed mineralogy. It contains varying numbers of pebbles, stones, and cobblestones. Boulders are common in some places. The main area of exposed glacial till is in the southwestern part of Richland County, shown as associations 1, 2, and 3 on the general soil map. The major soils that formed in glacial till are the Aastad, Forman, Barnes, Buse, and Svea soils.

The soils in the southern part of the Lake Agassiz plain, in southeastern Richland County, shown as association 13 on the general soil map, formed in a thin layer of medium-textured or moderately fine textured lacustrine sediments and the underlying clay loam glacial till. The soils that formed in this kind of material are the Antler, Doran, and Gilby soils.

Alluvium refers to material moved and redeposited by water. Recent alluvium consists of sediments deposited by flooding streams on bottom lands and terraces. Local alluvium is material that washed from hilltops and slopes and deposited on lower parts of slopes and in depressions and swales. The Cashel, Fairdale, LaDelle, Lamoure, LaPrairie, and Wahpeton soils formed in recent alluvium on bottom lands and terraces of the Sheyenne, Wild Rice, and Red Rivers and smaller tributary streams. Parnell and Tonka soils formed in local alluvium in depressions in the till plain.

Eolian sand in the survey area is on the Sheyenne Delta, mainly in association 5 on the general soil map. This sandy material was originally deposited in glacial Lake Agassiz and later was blown about by the wind into hummocks and dunes, some of which are as much as 50 feet high. The main soils that formed in eolian sands are the Serden soils. These soils have a low content of organic matter and do not have distinctive soil layers.

Climate

The survey area has a cool, dry, subhumid, continental climate. Summers are warm and relatively moist, and winters are generally cold and dry. Maximum summer temperatures commonly exceed 90° F. in July and August, and minimum winter temperatures frequently fall below 0° in December, January, and February. The soil generally is frozen from late in November to early in April. The average annual precipitation is about 20 inches. Of this amount, about 80 percent falls during the growing season, April through September. The climate is nearly uniform throughout the Area.

The principal effect of climate on soil formation has been the direct influence of rainfall and temperature on the weathering of the parent material, the leaching of carbonates, and the accumulation of organic matter in the surface layer. In addition, the climate determines the type of plant and animal life that influences soil development. Tall grasses are the dominant vegetation.

The chemical processes of weathering proceed at a relatively slow rate. In winter, chemical reactions and the activity of living organisms essentially come to a standstill. The slowdown in biological activity in winter favors the accumulation of organic matter.

Moderately well drained soils, such as the Aastad and Gardena soils, reflect the maximum influence of climate upon their development. These soils are leached of calcium carbonate to a depth of about 18 to 30 inches and leached of soluble salts to a greater depth. Under the prevailing climate these soils have accumulated much organic matter in the surface layer and have a high percentage of exchangeable bases.

Living organisms

The native vegetation has a great influence on soil formation. The kind of vegetation depends mainly on the prevailing climate. The soils in this survey area formed mainly under tall grasses.

The effect of living organisms on the formation of the soils has been mainly in the differentiation of horizons according to the accumulation of organic matter and plant nutrients. Soils that formed under grasses, for example, Svea soils, have a dark-colored surface layer because they contain an accumulation of organic matter. These soils also are high in exchangeable bases, because calcium, magnesium, and potassium have been translocated from the grass roots into stalks and leaves. When plants decay, these minerals are deposited into

the surface layer. For this reason, the soils are dominantly dark colored and rich in organic-matter content and exchangeable bases.

Relief

Relief influences soil formation by the way that it affects drainage, runoff, and erosion. The amount of water that enters a soil depends partly on topography. Steep soils generally have indistinct horizons, because the rapid runoff removes the weathered parent material nearly as fast as it forms. Because runoff is rapid, the steep soils also have less moisture available for plant growth and the formation of distinct horizons. Consequently, steep soils have indistinct horizons and are low in organic-matter content.

The influence of relief on soil formation is most evident in the soils on the glacial till plain in the southwestern part of Richland County. On this undulating to hilly topography, Buse and Langhei soils are on hilltops, ridges, and knolls, and Forman, Barnes, Aastad, and Svea soils are in undulating and level areas. Buse and Langhei soils have a thin A horizon that lies directly over the calcareous, unweathered parent material. The surface layer, or A horizon, of these soils is thin, because during soil formation moisture was scarce, vegetation was sparse, and erosion was very active. The associated Forman, Barnes, Aastad, and Svea soils have a thick A horizon, a well-developed B horizon, and a greater depth over a zone of lime accumulation. The deep concave depressions in this till plain receive large amounts of runoff and are frequently ponded because they lack outlets into streams and drainageways.

The soils that formed in these depressions are mainly Typic Argiaquolls of the Parnell series. These soils have a thick, dark-colored surface layer and a mottled dark-gray and olive-gray subsoil and substratum. The amount of moisture these soils receive far exceeds the normal precipitation for the area. As a result, the native vegetation was tall grasses and sedges, both of which added large amounts of organic matter to the surface layer. Mottling in the subsoil and substratum indicates the poor drainage under which these soils formed.

The soils in the rest of the survey area formed in the bed of glacial Lake Agassiz. All of this area, with the exception of the Sheyenne Delta, the Sandhills, and the slopes along the Sheyenne and Wild Rice Rivers, has low relief and nearly level topography. Surface relief in most parts of the lake plain is less than 5 feet to a square mile and in some places it is less than 1 foot per mile. Surface drainage is poor over much of the area and subsurface movement of water is very slow because the gradient is low. These conditions contributed to the formation of large acreages of Typic Haplaquolls, which are represented by the Hamar, Tiffany, and Perella series; the Vertic Haplaquolls of the Fargo series; the Aeric Calciaquolls of the Bearden, Glyndon, and Wyndmere series and Typic Calicaquolls of the Antler, Arveson, Borup, Colvin, Hegne, and Grano series.

Time

The length of time necessary for a soil to form depends on the other factors of soil formation. Soil formation is faster in a humid climate that has dense vegetation than in a dry climate that has sparse vegetation. Also, less time is required for a soil to form on glacial till than in hard bedrock.

From a geologic standpoint, the soils of this survey area are relatively young. The Mankato Drift, which is the parent material of most of the soils in the Area, has been exposed for less than 10,000 years. During this time many well-defined profiles have formed. The well-drained soils in the area, such as the Forman, Barnes, and Eckman soils have a well-defined profile that has a distinct A, B, and C horizon. On the other hand, the LaPrairie, Wahpeton, and Lamoure soils, which formed in recent alluvium, have few or no well-expressed horizons, other than the accumulation of large amounts of organic matter.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*4*, *6*).

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode or origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 10, the soil series of the survey area are placed in 3 categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is divided into suborders on the basis of those soil characteristics that seem to produce classes with the greatest genetic similarity. The sub-

TABLE 10.—*Soil series classified according to the current system*[1]

Series	Family	Subgroup	Order
Aastad	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Aberdeen	Fine, montmorillonitic	Glossic Udic Natriborolls	Mollisols.
Antler	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Arvilla	Sandy, mixed	Udic Haploborolls	Mollisols.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Bearden	Fine-silty, frigid	Aeric Calciaquolls	Mollisols.
Beotia	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Borup	Coarse-silty, frigid	Typic Calciaquolls	Mollisols.
Buse	Fine-loamy, mixed	Udorthentic Haploborolls	Mollisols.
Cashel	Fine, montmorillonitic, frigid	Mollic Udifluvents	Entisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Dickey	Sandy over loamy, mixed	Udic Haploborolls	Mollisols.
Doran	Fine, mixed	Aquic Argiborolls	Mollisols.
Dovray	Fine, montmorillonitic, frigid	Cumulic Haplaquolls	Mollisols.
Eckman	Coarse-silty, mixed	Udic Haploborolls	Mollisols.
Egeland	Coarse-loamy, mixed	Udic Haploborolls	Mollisols.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Enloe	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Exline	Fine, montmorillonitic	Leptic Natroborolls	Mollisols.
Fairdale	Fine-loamy, mixed, frigid	Mollic Udifluvents	Entisols.
Fargo	Fine, montmorillonitic, frigid	Vertic Haplaquolls	Mollisols.
Fordville	Fine-loamy over sandy or sandy-skeletal, mixed	Pachic Udic Haploborolls	Mollisols.
Forman	Fine-loamy, mixed	Udic Argiborolls	Mollisols.
Fossum	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Galchutt	Fine, montmorillonitic, frigid	Typic Argiabolls	Mollisols.
Gardena	Coarse-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Gilby	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Glyndon	Coarse-silty, frigid	Aeric Calciaquolls	Mollisols.
Grano	Fine, montmorillonitic, calcareous, frigid	Vertic Haplaquolls	Mollisols.
Hamar	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Hamerly	Fine-loamy, frigid	Aeric Calciaquolls	Mollisols.
Hecla	Sandy, mixed	Udic Haploborolls	Mollisols.
Hegne	Fine, frigid	Typic Calciaquolls	Mollisols.
Kratka	Sandy over loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
LaDelle	Fine-silty, mixed	Cumulic Udic Haploborolls	Mollisols.
Lamoure	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols.
Langhei	Fine-loamy, mixed, calcareous, frigid	Typic Udorthents	Entisols.
LaPrairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Mollisols.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Nutley	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Overly	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Parnell	Fine, montmorillonitic, frigid	Typic Argiaquolls	Mollisols.
Peever	Fine, montmorillonitic	Udic Argiborolls	Mollisols.
Perella	Fine-silty, mixed, frigid	Typic Haplaquolls	Mollisols.
Renshaw	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Roliss	Fine-loamy, mixed, calcareous, frigid	Typic Haplaquolls	Mollisols.
Ryan	Fine, montmorillonitic, frigid	Typic Natraquolls (Leptic)	Mollisols.
Serden	Mixed, frigid	Typic Udipsamments	Entisols.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Stirum	Coarse-loamy, mixed, frigid	Typic Natraquolls	Mollisols.
Svea	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Tiffany	Coarse-loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Towner	Sandy over loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Ulen	Sandy, mixed	Aquic Haploborolls (Calciborolls)	Mollisols.
Vallers	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Venlo	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Wahpeton	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Wyndmere	Coarse-loamy, frigid	Aeric Calciaquolls	Mollisols.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols.

[1] Classification as of April 1973.

orders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth, soil climate, the accumulation of clay, iron, or organic carbon in the upper parts of the solum, cracking of soils caused by a decrease in soil moisture, and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is Aquoll (*Aqu,* meaning water or wet, and *oll,* from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Haplaquoll (*Hapl,* meaning simple horizons, *aqu* for wetness or water, and *oll,* from Mollisols).

SUBGROUP. Each great group is divided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplaquolls (a typical Haplaquoll).

FAMILY. Soil families are established within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineral composition, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, clay composition, and so on, that are used as family differentiae (see table 10). An example is the coarse-loamy, mixed, mesic family of Typic Haplaquolls.

Environmental Factors Affecting Soil Use

This section was written for those who are not familiar with Richland County and the Sheyenne National Grassland Area of Ransom County. It describes briefly the physiography, relief, drainage, climate, and the water supply and gives some agricultural statistics that highlight some trends in use of the soil.

Physiography, Relief, and Drainage

Three main physiographic areas make up the survey area. These are the glacial till plain, the Sheyenne Delta, and the Lake Agassiz plain (*2*).

The till plain occupies about 300 square miles in the southwestern part of Richland County. It is about 1,100 to 1,250 feet above sea level and is lowest in the northern part. The soils of the till plain are nearly level to hilly. Slopes are mostly short, choppy, and irregular. Many scattered, closed depressions, marshes, and small lakes occur throughout the Area. Local relief is commonly 50 to 75 feet within a square mile, but it is more than 150 feet in some of the hilly areas. Surface drainage is poor. Most of the runoff collects in the closed depressions, marshes, and small lakes. All streams are intermittent and commonly flow into marshes or lakes.

The Sheyenne Delta covers all of the survey area that is in Ransom County and about 550 square miles in the northwestern part of Richland County. A large part of the delta is nearly level or gently undulating, but it contains many areas of dunes where local relief is as much as 50 feet within a square mile. The northern part of the delta is about 100 feet above the lake plain and it gradually merges into the lake plain at its southern and eastern sides. The Sheyenne River flows through the delta in a steep-sided valley that is 120 feet deep in places.

Otherwise, the drainage pattern over most of the delta is poorly developed. Most of the soils on the delta have rapid or moderately rapid permeability, and nearly all rainfall enters the soil. Permanent ponding is rare, but there are many shallow depressions and flats that are occasionally ponded and that have a water table within 1 to 3 feet of the surface during most of the growing season.

The lake plain is nearly flat. It is about 925 to 1,065 feet above sea level and is lowest in the northern part of Richland County. Except for a few beach areas and stream valleys, the local relief commonly is less than 5 feet within a square mile and many areas have differences in elevation of less than 1 foot to a mile. The Red River of the North and the Wild Rice River flow in a northerly and northeasterly direction through the lake plain. Otherwise, the surface drainage throughout this physiographic area is poor. Most of the runoff is removed from the area through manmade drainage ditches that have outlets into the Red River and the Wild Rice River.

Water Supply

The water supply in the survey area is obtained mainly from wells drilled into the ground water. The mantle of glacial drift covering the survey area is 154 to 490 feet thick. Most of the water is obtained from aquifers in the glacial drift, but some wells are drilled into aquifers in the bedrock (*3*).

The two most important aquifers in the survey area are in shoreline deposits of glacial Lake Agassiz. The largest and potentially the most productive of these is the Sheyenne Delta aquifer. The other is in the Lake Agassiz beach deposits near the city of Hankinson.

The Sheyenne Delta aquifer has an area of about 300 square miles in northwestern Richland County, and it extends into the Sheyenne National Grassland Area of Ransom County. The Hankinson aquifer has an area of about 100 square miles. The water in these aquifers is hard, but it is of good quality for drinking and it is suitable for irrigation. These aquifers are relatively undeveloped, but they supply water for the cities of

Wyndmere and Hankinson. Many farmers and ranches in the area also tap these aquifers for their domestic water supply.

Other glacial drift aquifers of lesser size and importance are in the sandy and gravelly deposits in the Milnor channel near Lidgerwood, in glacial outwash deposits in Brightwood Township southwest of Hankinson, and in buried glacial outwash near Fairmount and Colfax. These aquifers provide water for municipalities and farmers in their vicinity.

The bedrock aquifers in the survey area are in the Dakota Sandstone and Precambrian Granite Formations. The Dakota Sandstone is by far the more productive of the two. It underlies all of the survey area except the northeastern part of Richland County, which is underlain by Precambrian granite. The wells in the bedrock aquifers are 200 to 900 feet deep. The water is under artesian pressure that is great enough for most of the wells to flow at the surface. The water from the bedrock aquifers is highly mineralized with concentrations of chloride and sulfate and generally is of poor quality for drinking. It is unsuitable for irrigation because the content of sodium is high. Most of the water from the bedrock aquifers is used for watering livestock. The city of Wahpeton, however, uses water from the Dakota Sandstone Formation in its municipal water supply after it has been mixed with treated surface water from the Ottertail River.

Climate[8]

Richland County has a continental climate. Summers are pleasantly warm. Winters are long and cold, but there generally are a few mild periods in winter when temperatures are above freezing. About 85 percent of the precipitation falls in the period April through October. Climatological data from Wahpeton are summarized in table 11.

The normal daily range in temperature is about 21° F in winter and 28° in midsummer. Cold fronts occasionally cause temperatures to drop as much as 40 or 50 degrees within a 24 hour period. Average maximum temperatures equal or exceed 90° on about 20 days annually, three-fourths of which occur in July and August. The greatest likelihood of 5 or more consecutive days of temperatures above 90° is in the last 2 weeks of July when the chances are about 1 in 7. Minimum temperatures are freezing or below on about 180 days a year, and 0° or below on about 50 days a year.

The average length of the freeze-free period is about 130 days. No time of the year can be considered absolutely frost free or freeze free. The lighter soils in the area of the Sheyenne Delta and in the depressions in the glacial till area in the southwest part of the county are the most susceptible to midsummer radiation frosts as well as frosts late in spring and early in summer.

Average annual precipitation ranges from about 19.5 inches in the northern part of the county to more than 21 inches in the extreme southwestern part. Annual rainfall can vary widely. At Wahpeton, annual rainfall during this century has varied from 10.74 to 36.29 inches. Normally 0.01 inch or more of precipitation is

[8] By MORTON BAILEY, climatologist for North Dakota, National Weather Service, U.S. Department of Commerce.

TABLE 11.—*Temperature and precipitation*

[Data recorded at Wahpeton, Richland County, for 70-year period from 1901 to 1970. Data on extremes of temperature and on snowfall are for period from 1931 to 1960]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with— Maximum temperature equal to or higher than—	Two years in 10 will have at least 4 days with— Minimum temperature equal to or lower than—	Average total	One year in 10 will have— Less than—	One year in 10 will have— More than—	Days with snow cover	Average depth of snow on days with snow cover
					Inches	*Inches*	*Inches*	*Number*	*Inches*
January	19.3	−1.7	40.0	−25.2	0.50	0.1	1.2	29	7
February	23.7	2.4	42.9	−23.2	0.49	.1	1.2	28	7
March	37.9	17.4	57.7	−8.4	0.73	.1	1.6	19	5
April	56.5	31.7	75.5	14.4	2.14	.6	3.6	3	1
May	69.8	42.8	88.6	26.6	2.68	.9	4.8	(1)	1
June	78.3	53.0	93.4	38.5	3.87	1.4	6.6	0	0
July	84.7	57.8	98.5	46.0	3.08	1.1	5.7	0	0
August	83.4	55.6	97.3	42.0	2.74	.8	4.8	0	0
September	73.2	46.3	92.3	29.2	2.09	.6	4.0	0	0
October	60.8	35.2	82.2	17.7	1.31	.2	2.6	(1)	1
November	40.1	20.1	62.8	−2.7	0.74	.1	1.8	5	2
December	25.4	5.5	44.7	−18.6	0.57	.1	1.4	23	4
Year	54.4	30.5	[2] 100.0	[3] −28.0	20.94	15.7	26.6	107	5

[1] Less than 0.5 day. [2] Average annual highest temperature. [3] Average annual lowest temperature.

received on 105 days each year, and 0.11 inch or more is received on 47 days.

Over a 20-year period, hail can be expected on 45 days in the northern part of the county and on as much as 60 days in the southeast corner. Most hail occurs in June and July. Damaging hail is much less frequent. Normally only one or two areas of a few square miles receive serious hail damage each year.

Average annual snowfall is approximately 36 inches. About 5 to 7 inches of snow normally falls in each of the months from December through March. Snow occasionally falls in May and September. Blizzards occur nearly every year, and blowing snow restricts visibility several times each winter.

The annual evaporation from a Class A pan averages about 40 inches in the northeastern part of the county and 42 inches in the southwestern part. About 85 percent of the evaporation takes place in the period May through October. The annual evaporation from lakes has been estimated at about 31 inches.

Richland County receives 59 percent of the possible sunshine annually. July, averaging 73 percent of the possible sunshine, is the sunniest month. November and January are the cloudiest months, averaging only 39 percent of the possible sunshine.

The prevailing wind in Richland County is north or northwesterly from November through May. The average wind velocity ranges from 14 to 16 miles per hour. From June to October the prevailing winds are from the southeast or south and average 11 to 13 miles per hour. Winds from all directions occur in every month. They usually blow from one direction for only a few days at a time.

A considerable acreage in the county is subject to flooding along the Red, Bois de Sioux, and Wild Rice Rivers. The floods generally are seasonal in nature and occur in March or April resulting from snowmelt in spring. During the past 25 years, the Red River at Wahpeton has exceeded flood stage on an average of nearly every other year. Extensive flooding of areas not along the rivers has also occurred at other times when locally heavy rains have fallen.

Farming

Most of the survey area is farmed. In Richland County alone, about 93 percent of the land is in farms (*7*).[9] In recent years the trend is toward fewer and larger farms. At present, about 1,627 farms are operated in Richland County, a decrease of about 700 in the last 15 years. During the same period the average farm increased in size by about 160 acres. The farms now being operated in Richland County range from less than 100 acres to more than 2,000 acres in size and average 529 acres. The farms are mainly of the cash-grain, livestock, and general crop and livestock types. A few are dairy and poultry farms. Full owners operate 588 farms, part owners operate 721 farms, and tenants operate 318 farms.

[9] Agricultural statistics for the Sheyenne National Grassland Area in Ransom County are available from the District Ranger's office at Lisbon.

The main field crops in Richland County are corn, soybeans, spring wheat, oats, barley, and alfalfa. The acreage of these crops varies from year to year according to Federal farm programs in effect and weather conditions. Soybeans and wheat are the main cash crops. Most of the corn, oats, and barley is fed to livestock on the farm and in feedlots, but some is sold on the cash-grain market. One of the more striking trends in recent years is the large increase in the acreage of soybeans. During the past 15 years the acreage of this crop has expanded from about 30,000 acres to more than 104,000 acres. Sugar beets is an important crop for a few farmers who have contracts with nearby sugar beet processing plants. The acreage of this crop will be greatly expanded when a processing plant now planned near Wahpeton is constructed.

More than 60 percent of the farms produce livestock. Cattle and hogs are the main kinds of livestock, but some farmers raise sheep. Most of the beef herds are of the cow-calf type. They range in size from fewer than 20 head of cattle and calves to more than 500 head. The larger herds are mainly on ranch-type farms on the Sheyenne Delta sandhills where there is an abundance of native-grass pasture. Hereford, Aberdeen Angus, and Shorthorn are the most popular breeds of beef cattle. Many of the grass-fed calves and yearlings are sold at auction and are fattened locally or are shipped outside the county. There are several good-sized cattle feeding operations in the county that feed more than 1,000 head each year.

Transportation and Markets

U.S. Highway No. 81 and State Highways 46, 27, 18, 13, and 11 provide ready access to markets, both within and outside the survey area. Interstate Highway 29, which is under construction in the eastern part of Richland County, should be completed by 1975. At the time of the survey, the Burlington Northern, the Soo Line, and the Chicago, Milwaukee, St. Paul, and Pacific Railroads provided rail transportation for the survey area. There are no commercial airline facilities, but the Wahpeton Airport provides charter flights, aircraft rental, and other flying services.

Wahpeton is the principal trade and marketing center. It has a livestock auction market, dairy and poultry processing plants, grain-marketing facilities, and several small manufacturing plants. A sugar beet processing plant is planned for the Wahpeton area. Most of the small grain, corn, and soybeans sold in the area is marketed through small town grain elevators and is shipped to Minneapolis, Duluth, and other large terminal markets.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well-aerated soil is similar to that in the atmosphere; but that in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Contour farming. Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by melt water as it flowed from glacial ice.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Relief. The elevations or inequalities of a land surface, considered collectively.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Sodic. Of, pertinent to, or containing sodium.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, page 11.
Predicted yields, table 2, page 77.
Wildlife, table 4, page 87.
Recreation, table 5, page 90.
Engineering, tables 6, 7, 8, and 9, pages 98 to 131.

Map symbol	Mapping unit	Page	Capability unit		Range site		Windbreak group
			Symbol	Page	Name	Page	Number
Af	Aastad-Forman loams	14	IIc-6	70	---------	--	--
	Aastad soil	--	------	--	Overflow	80	1
	Forman soil	--	------	--	Silty	82	3
Ag	Aberdeen fine sandy loam	14	IIIe-3P	72	Silty	82	4
Ah	Aberdeen silt loam	14	IIIs-P6	74	Clayey	82	4
Ak	Aberdeen-Galchutt silty clay loams	15	IIIs-P6	74	---------	--	--
	Aberdeen soil	--	------	--	Clayey	82	4
	Galchutt soil	--	------	--	Silty	82	1
Ao	Aberdeen-Ryan silty clay loams	15	IIIs-P4	74	---------	--	--
	Aberdeen soil	--	------	--	Clayey	82	4
	Ryan soil	--	------	--	Thin Claypan	82	9
Ar	Antler silty clay loam	15	IIe-4L	69	Silty	82	1
As	Antler-Tonka silty clay loams	16	IIe-4L	69	---------	--	--
	Antler soil	--	------	--	Silty	82	1
	Tonka soil	--	------	--	Wet Meadow	80	2
At	Arveson-Fossum fine sandy loams	16	IIIwe-3	73	Wet Meadow	80	2
Au	Arveson and Fossum loams	16	IIw-4L	70	Wet Meadow	80	2
Av	Arveson and Fossum loams, very wet	16	Vw-WL	75	Wetland	80	2
Aw	Arvilla fine sandy loam	18	IIIes-3	72	Shallow to gravel	82	6
BbD	Barnes-Buse loams, hilly	18	IVe-6	75	---------	--	--
	Barnes soil	--	------	--	Silty	82	3
	Buse soil	--	------	--	Thin Upland	81	8
BbD2	Barnes-Buse loams, hilly, eroded	19	IVe-6	75	---------	--	--
	Barnes soil	--	------	--	Silty	82	3
	Buse soil	--	------	--	Thin Upland	81	8
BcD	Barnes-Buse-Langhei loams, hilly	19	VIe-TU	75	---------	--	--
	Barnes soil	--	------	--	Silty	82	3
	Buse soil	--	------	--	Thin Upland	81	8
	Langhei soil	--	------	--	Thin Upland	81	8
BdB	Barnes-Svea loams, undulating	19	IIe-6	69	Silty	82	--
	Barnes soil	--	------	--	---------	--	3
	Svea soil	--	------	--	---------	--	1
Bf	Bearden silty clay loam	20	IIe-4L	69	Silty	82	1
Bg	Bearden and Glyndon silt loams, moderately deep over clay	20	IIe-4L	69	Silty	82	1
Bo	Borup loam	22	IIw-4L	70	Wet Meadow	80	2
Br	Borup silt loam, very wet	22	Vw-WL	75	Wetland	80	2
Ca	Cashel silty clay	23	IIs-4	70	Overflow	80	1
Co	Colvin silty clay loam	24	IIw-4L	70	Wet Meadow	80	2
DkB	Dickey-Towner fine sandy loams, undulating	24	IIIe-3M	71	Sandy	81	--
	Dickey soil	--	------	--	---------	--	5
	Towner soil	--	------	--	---------	--	1
Do	Doran clay loam	25	IIc-6	70	Clayey	82	1
Dp	Doran-Perella clay loams	25	IIw-6	70	---------	--	--
	Doran soil	--	------	--	Clayey	82	1
	Perella soil	--	------	--	Wet Meadow	80	2
Dt	Doran-Tonka silty clay loams	25	IIw-6	70	---------	--	--
	Doran soil	--	------	--	Clayey	82	1
	Tonka soil	--	------	--	Wet Meadow	80	2

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Range site[1] Name	Range site Page	Windbreak group Number
Dv	Dovray silty clay	26	IIIw-4	73	Wetland	80	2
EeC	Eckman-Zell silt loams, rolling	26	IIIe-5	72	---------	--	--
	Eckman soil	--	------	--	Silty	82	3
	Zell soil	--	------	--	Thin Upland	81	8
EmB	Egeland and Maddock fine sandy loams, undulating	27	IIIe-3	71	Sandy	81	5
En	Embden-Tiffany fine sandy loams	28	IIIe-3	71	---------	--	--
	Embden soil	--	------	--	Sandy	81	1
	Tiffany soil	--	------	--	Subirrigated	80	2
Et	Embden-Tiffany loams	28	IIe-5	69	---------	--	--
	Embden soil	--	------	--	Sandy	81	1
	Tiffany soil	--	------	--	Subirrigated	80	2
Ey	Exline and Ryan soils	30	VIs-TCp	76	Thin Claypan	82	9
Fa	Fairdale silt loam	30	IIc-6	70	Overflow	80	1
Fb	Fairdale silt loam, channeled	30	IIe-6	69	Silty	82	1
Fd	Fairdale silty clay loam	30	IIc-6	70	Overflow	80	1
Fe	Fargo silty clay loam	31	IIw-6	70	Clayey	82	1
Ff	Fargo silty clay	31	IIwe-4	70	Clayey	82	1
Fg	Fargo silty clay, depressional	31	IIwe-4	70	Clayey	82	1
FhB	Fargo silty clay, gently sloping	31	IIe-4	69	Clayey	82	1
Fk	Fargo silty clay, till substratum	31	IIwe-4	70	Clayey	82	1
Fm	Fargo-Enloe silty clay loams	32	IIw-6	70	---------	--	--
	Fargo soil	--	------	--	Clayey	82	1
	Enloe soil	--	------	--	Wet Meadow	80	2
Fn	Fargo-Enloe complex, till substratum	32	IIwe-4	70	---------	--	--
	Fargo soil	--	------	--	Clayey	82	1
	Enloe soil	--	------	--	Wet Meadow	80	2
Fo	Fargo-Hegne silty clays	33	IIwe-4	70	Clayey	82	1
Fp	Fargo-Hegne silty clays, till substratum	33	IIwe-4	70	Clayey	82	1
Fr	Fargo-Ryan silty clay loams	33	IIIs-P4	74	---------	--	--
	Fargo soil	--	------	--	Clayey	82	1
	Ryan soil	--	------	--	Thin Claypan	82	9
Fs	Fargo-Ryan silty clays	33	IIIs-P4	74	---------	--	--
	Fargo soil	--	------	--	Clayey	82	1
	Ryan soil	--	------	--	Thin Claypan	82	9
Ft	Fordville-Renshaw loams	34	IIIs-5	74	---------	--	--
	Fordville soil	--	------	--	Silty	82	3
	Renshaw soil	--	------	--	Shallow to Gravel	82	6
FuB	Forman-Aastad loams, undulating	35	IIe-6	69	---------	--	--
	Forman soil	--	------	--	Silty	82	3
	Aastad soil	--	------	--	Overflow	80	1
FuB2	Forman-Aastad loams, undulating, eroded	35	IIe-6	69	---------	--	--
	Forman soil	--	------	--	Silty	82	3
	Aastad soil	--	------	--	Overflow	80	1
FvC	Forman-Buse loams, rolling	35	IIIe-6	72	---------	--	--
	Forman soil	--	------	--	Silty	82	3
	Buse soil	--	------	--	Thin Upland	81	8
FvC2	Forman-Buse loams, rolling, eroded	36	IIIe-6	72	---------	--	--
	Forman soil	--	------	--	Silty	82	3
	Buse soil	--	------	--	Thin Upland	81	8
FwB	Forman-Peever clay loams, undulating	36	IIe-6	69	---------	--	--
	Forman soil	--	------	--	Silty	82	3
	Peever soil	--	------	--	Clayey	82	4
Fx	Fossum fine sandy loam	36	IIIwe-3	73	Wet Meadow	80	2
Ga	Galchutt silt loam	37	IIw-6	70	Silty	82	1

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Range site Name	Range site Page	Windbreak group Number
Gc	Galchutt-Enloe-Fargo complex	37	IIw-6	70	---------	--	--
	Galchutt soil	--	------	--	Silty	82	1
	Enloe soil	--	------	--	Wet Meadow	80	2
	Fargo soil	--	------	--	Clayey	82	1
Gd	Galchutt-Overly silt loams	38	IIc-6	70	Silty	82	1
Ge	Gardena silt loam	39	IIe-5	69	Silty	82	1
GfB	Gardena-Eckman silt loams, undulating	39	IIe-5	69	Silty	82	--
	Gardena soil	--	------	--	---------	--	1
	Eckman soil	--	------	--	---------	--	3
Gh	Gardena and Embden loams	39	IIe-5	69	---------	--	1
	Gardena soil	--	------	--	Silty	82	--
	Embden soil	--	------	--	Sandy	81	--
Gk	Gilby silt loam	39	IIe-4L	69	Silty	82	1
Gm	Gilby silt loam, moderately saline	40	IIIs-4L	73	Subirrigated	80	10
Gn	Gilby and Hamerly loams	40	IIe-4L	69	Silty	82	1
Go	Glyndon silt loam	41	IIe-4L	69	Silty	82	1
Gr	Glyndon-Tiffany very fine sandy loams	41	IIe-4L	69	---------	--	--
	Glyndon soil	--	------	--	Silty	82	1
	Tiffany soil	--	------	--	Subirrigated	80	2
Gt	Glyndon-Tiffany loams, moderately deep over clay	41	IIe-4L	69	---------	--	--
	Glyndon soil	--	------	--	Silty	82	1
	Tiffany soil	--	------	--	Subirrigated	80	2
Gu	Glyndon and Wyndmere loams	41	IIe-4L	69	---------	--	1
	Glyndon soil	--	------	--	Silty	82	--
	Wyndmere soil	--	------	--	Sandy	81	--
Gw	Grano clay	42	IIIw-4	73	Wetland	80	2
Ha	Hamar loamy fine sand	43	IVwe-2	75	Subirrigated	80	2
Hb	Hamar loamy fine sand, moderately deep over clay	43	IVwe-2	75	Subirrigated	80	2
Hc	Hamar fine sandy loam	43	IIIwe-3	73	Subirrigated	80	2
He	Hamar fine sandy loam, moderately deep over clay	43	IIIwe-3	73	Subirrigated	80	2
Hf	Hamar-Ulen loamy fine sands	43	IVwe-2	75	----------	--	--
	Hamar soil	--	------	--	Subirrigated	80	2
	Ulen soil	--	------	--	Sands	81	1
Hg	Hamar-Ulen fine sandy loams	43	IIIwe-3	73	---------	--	--
	Hamar soil	--	------	--	Subirrigated	80	2
	Ulen soil	--	------	--	Sandy	81	1
Hh	Hamerly loam	44	IIe-4L	69	Silty	82	1
Hk	Hecla loamy fine sand, loamy substratum	45	IVe-2	74	Sands	81	1
Hm	Hecla-Hamar loamy fine sands	45	IVe-2	74	---------	--	--
	Hecla soil	--	------	--	Sands	81	1
	Hamar soil	--	------	--	Subirrigated	80	2
Hm3	Hecla-Hamar loamy fine sands, severely eroded	46	VIe-Sa	75	---------	--	--
	Hecla soil	--	------	--	Sands	81	1
	Hamar soil	--	------	--	Subirrigated	80	2
Hn	Hecla-Hamar fine sandy loams	46	IIIe-3	71	---------	--	--
	Hecla soil	--	------	--	Sandy	81	1
	Hamar soil	--	------	--	Subirrigated	80	2
Ho	Hecla-Hamar-Arveson complex	46	IVe-2	74	---------	--	--
	Hecla soil	--	------	--	Sands	81	1
	Hamar soil	--	------	--	Subirrigated	80	2
	Arveson soil	--	------	--	Wet Meadow	80	2
Hr	Hecla-Maddock loamy sands	46	IVe-2	74	Sands	81	--
	Hecla soil	--	------	--	---------	--	1
	Maddock soil	--	------	--	---------	--	5

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Range site Name	Range site Page	Windbreak group Number
Hs	Hecla-Maddock sandy loams	46	IIIe-3	71	Sandy	81	--
	Hecla soil	--	------	--	---------	--	1
	Maddock soil	--	------	--	---------	--	5
Kr	Kratka fine sandy loam	47	IIIwe-3	73	Subirrigated	80	2
La	LaDelle silty clay loam	48	IIc-6	70	Overflow	80	1
Lb	LaDelle and Wahpeton soils, channeled	48	VIe-Ov	75	---------	--	1
	LaDelle soil	--	------	--	Overflow	80	--
	Wahpeton soil	--	------	--	Clayey	82	--
Lm	Lamoure silty clay loam	49	IIw-4L	70	Subirrigated	80	2
Lp	LaPrairie silt loam	49	IIc-6	70	Overflow	80	1
MdC	Maddock loamy fine sand, rolling	50	VIe-Sa	75	Sands	81	5
MhB	Maddock-Hecla loamy fine sands, undulating	50	IVe-2	74	Sands	81	--
	Maddock soil	--	------	--	---------	--	5
	Hecla soil	--	------	--	---------	--	1
M1B	Maddock-Hecla-Hamar loamy fine sands, undulating	50	IVe-2	74	---------	--	--
	Maddock soil	--	------	--	Sands	81	5
	Hecla soil	--	------	--	Sands	81	1
	Hamar soil	--	------	--	Subirrigated	80	2
Mr	Marsh	51	VIIIw-1	76	---------	--	--
NuC	Nutley silty clay, rolling	51	IIIe-4	72	Clayey	82	4
Oc	Overly silty clay loam	52	IIc-6	70	Silty	82	1
Od	Overly-Bearden silt loams, moderately saline	52	IIIs-4L	73	---------	--	10
	Overly soil	--	------	--	Silty	82	--
	Bearden soil	--	------	--	Subirrigated	80	--
Oe	Overly-Bearden silty clay loams, moderately saline	52	IIIs-4L	73	---------	--	10
	Overly soil	--	------	--	Silty	82	--
	Bearden soil	--	------	--	Subirrigated	80	--
O1B	Overly-Beotia silty clay loams, undulating	52	IIe-6	69	Silty	82	--
	Overly soil	--	------	--	---------	--	1
	Beotia soil	--	------	--	---------	--	3
Pc	Parnell silty clay loam	53	IIIw-6	73	Wetland	80	2
Pd	Parnell and Tonka silty clay loams	53	IIw-6	70	---------	--	2
	Parnell soil	--	------	--	Wetland	80	--
	Tonka soil	--	------	--	Wet Meadow	80	--
Pe	Peat	53	Vw-WL	75	Wetland	80	10
Pf	Peever-Forman clay loams	54	IIc-6	70	---------	--	--
	Peever soil	--	------	--	Clayey	82	4
	Forman soil	--	------	--	Silty	82	3
Pr	Perella loam, moderately deep over clay	55	IIw-6	70	Wet Meadow	80	2
Ps	Perella silty clay loam, moderately deep over clay	55	IIw-6	70	Wet Meadow	80	2
Ro	Roliss clay loam	56	IIIw-6	73	Subirrigated	80	2
Ry	Ryan-Fargo complex	57	IIIs-P4	74	---------	--	--
	Ryan soil	--	------	--	Thin Claypan	82	9
	Fargo soil	--	------	--	Clayey	82	1
Sd	Serden loamy fine sand	57	VIIe-TSa	76	Thin Sands	81	10
Se	Serden-Stabilized dune land complex	57	VIIe-TSa	76	Thin Sands	81	10
ShB	Sioux-Renshaw complex, undulating	58	VIs-VS	76	---------	--	--
	Sioux soil	--	------	--	Very Shallow	81	10
	Renshaw soil	--	------	--	Shallow to Gravel	82	6
ShE	Sioux-Renshaw complex, hilly	59	VIs-VS	76	---------	--	10
	Sioux soil	--	------	--	Very Shallow	81	--
	Renshaw soil	--	------	--	Shallow to Gravel	82	--
Sr	Stirum-Arveson loams	59	IIIws-4L	73	---------	--	--
	Stirum soil	--	------	--	Subirrigated	80	9
	Arveson soil	--	------	--	Wet Meadow	80	2

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Range site Name	Range site Page	Windbreak group Number
St	Strongly saline land	60	VIs-SL	76	---------	--	10
Su	Svea loam	60	IIc-6	70	Overflow	80	1
SvB	Svea-Buse loams, undulating	60	IIe-6	69	---------	--	--
	Svea soil	--	------	--	Silty	82	1
	Buse soil	--	------	--	Thin Upland	81	8
SvC	Svea-Buse loams, rolling	61	IIIe-6	72	---------	--	--
	Svea soil	--	------	--	Silty	82	1
	Buse soil	--	------	--	Thin Upland	81	8
Sw	Svea-Gardena loams	61	IIc-6	70	---------	--	1
	Svea soil	--	------	--	Overflow	80	--
	Gardena soil	--	------	--	Silty	82	--
Sy	Swenoda-Wyndmere fine sandy loams	61	IIIe-3M	71	Sandy	81	1
Td	Tiffany fine sandy loam	62	IIIwe-3	73	Subirrigated	80	2
Tf	Tiffany loam	62	IIw-6	70	Subirrigated	80	2
Th	Tiffany loam, moderately deep over clay	62	IIw-6	70	Subirrigated	80	2
Tk	Tonka silt loam	63	IIw-6	70	Wet Meadow	80	2
To	Towner loamy fine sand	64	IVe-2	74	Sands	81	1
Tw	Towner and Swenoda fine sandy loams	64	IIIe-3M	71	Sandy	81	1
Un	Ulen fine sandy loam	65	IIIe-3	71	Sandy	81	1
Va	Vallers clay loam	65	IIw-4L	70	Wet Meadow	80	2
Ve	Venlo fine sandy loam	66	Vw-WL	75	Wetland	80	2
Wa	Wahpeton silty clay	66	IIs-4	70	Clayey	82	1
We	Wet alluvial land	66	Vw-WL	75	Wetland	80	10
Wy	Wyndmere fine sandy loam	67	IIIe-3	71	Sandy	81	1
ZeD	Zell-Eckman silt loams, hilly	67	IVe-6	75	---------	--	--
	Zell soil	--	------	--	Thin Upland	81	8
	Eckman soil	--	------	--	Silty	82	3
ZeE	Zell-Eckman silt loams, steep	67	VIe-TU	75	---------	--	8
	Zell soil	--	------	--	Thin Upland	81	--
	Eckman soil	--	------	--	Silty	82	--

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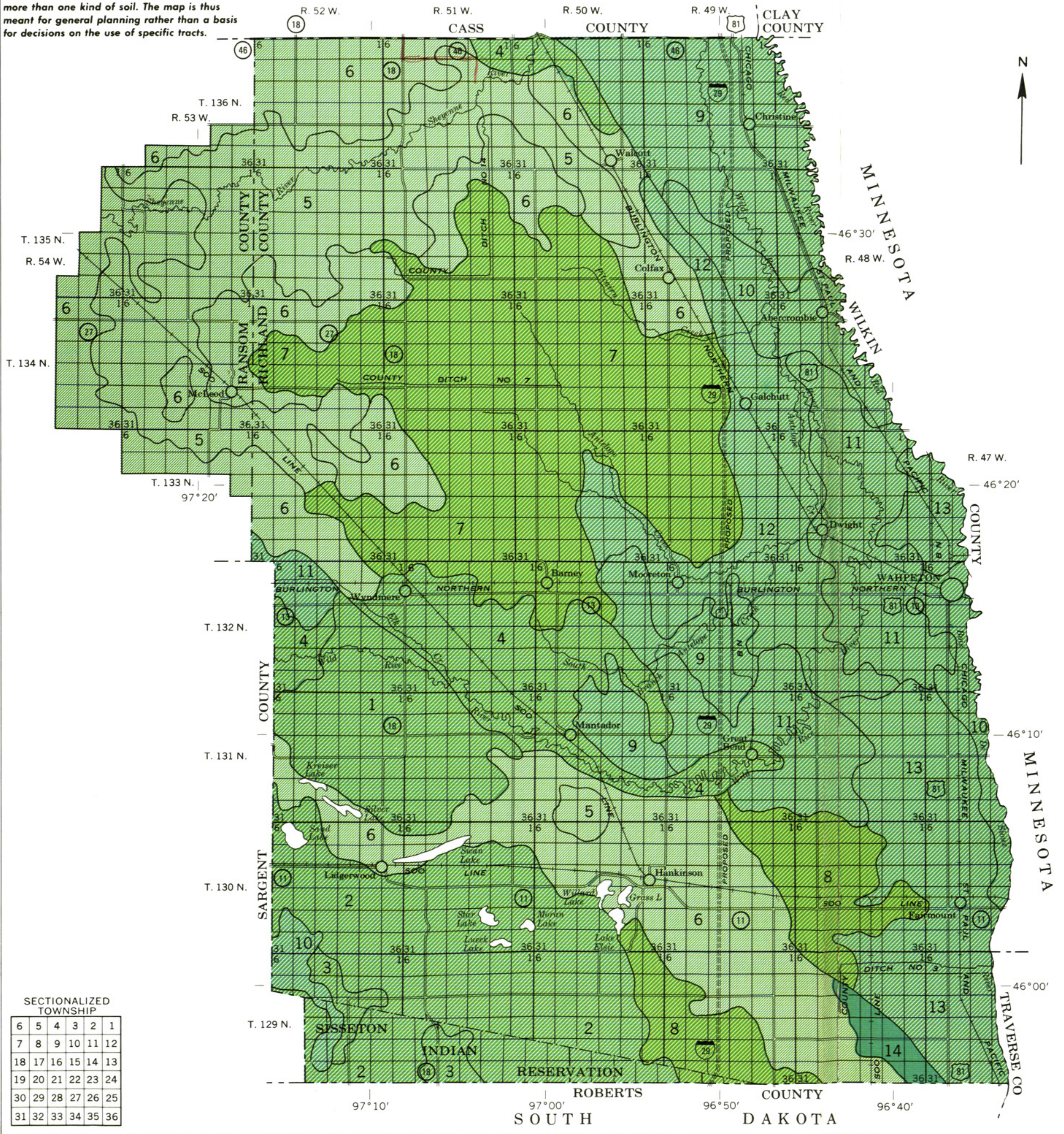
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FOREST SERVICE

NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

RICHLAND COUNTY, AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA

Scale 1:316,800

1 0 1 2 3 4 5 Miles

SOIL ASSOCIATIONS*

DEEP, NEARLY LEVEL TO HILLY, WELL DRAINED AND MODERATELY WELL DRAINED, MEDIUM TEXTURED AND MODERATELY FINE TEXTURED SOILS; ON TILL PLAINS AND LAKE PLAINS

1 Aastad-Forman-Svea association: Nearly level to undulating, well drained and moderately well drained, medium-textured soils formed in loamy glacial till

2 Forman-Aastad-Buse association: Nearly level to hilly, well drained and moderately well drained, medium-textured soils formed in loamy glacial till

3 Peever-Forman association: Nearly level to undulating, well-drained, moderately fine textured soils formed in loamy glacial till

4 Overly-Gardena association: Nearly level, moderately well drained, medium textured and moderately fine textured soils formed in silty lacustrine sediments

DEEP, NEARLY LEVEL TO HILLY, EXCESSIVELY DRAINED TO VERY POORLY DRAINED, COARSE-TEXTURED TO MEDIUM-TEXTURED SOILS; ON THE DELTA AND INTERBEACH AREA

5 Serden-Maddock association: Gently undulating to hilly, excessively drained and well drained, coarse-textured soils formed in sandy lacustrine and eolian materials

6 Hecla-Hamar-Arveson association: Nearly level to undulating, moderately well drained to very poorly drained, coarse-textured to medium-textured soils formed in sandy and loamy lacustrine sediments

DEEP, NEARLY LEVEL, MODERATELY WELL DRAINED TO POORLY DRAINED, MODERATELY COARSE TEXTURED AND MEDIUM TEXTURED SOILS; ON THE DELTA AND LAKE PLAIN

7 Embden-Glyndon-Tiffany association: Nearly level, moderately well drained to poorly drained, moderately coarse textured and medium textured soils formed in loamy and silty lacustrine sediments; some are shallow over lime

8 Glyndon-Gardena association: Nearly level, moderately well drained and somewhat poorly drained, medium-textured soils formed in silty lacustrine sediments; some are shallow over lime

DEEP, NEARLY LEVEL, SOMEWHAT POORLY DRAINED AND POORLY DRAINED, MEDIUM-TEXTURED TO FINE-TEXTURED SOILS; ON THE LAKE PLAIN

9 Fargo association: Nearly level, poorly drained, fine-textured soils formed in clayey lacustrine sediments

10 Fargo-Hegne association: Nearly level, poorly drained, fine-textured soils formed in clayey lacustrine sediments; some are shallow over lime

11 Fargo-Ryan association: Nearly level, poorly-drained, fine textured and moderately fine textured soils formed in clayey lacustrine sediments; some are very shallow over sodic claypan subsoil

12 Galchutt-Fargo-Aberdeen association: Nearly level, somewhat poorly drained and poorly drained, medium textured to moderately fine textured soils formed in silty and clayey lacustrine sediments; some are shallow over a sodic claypan subsoil

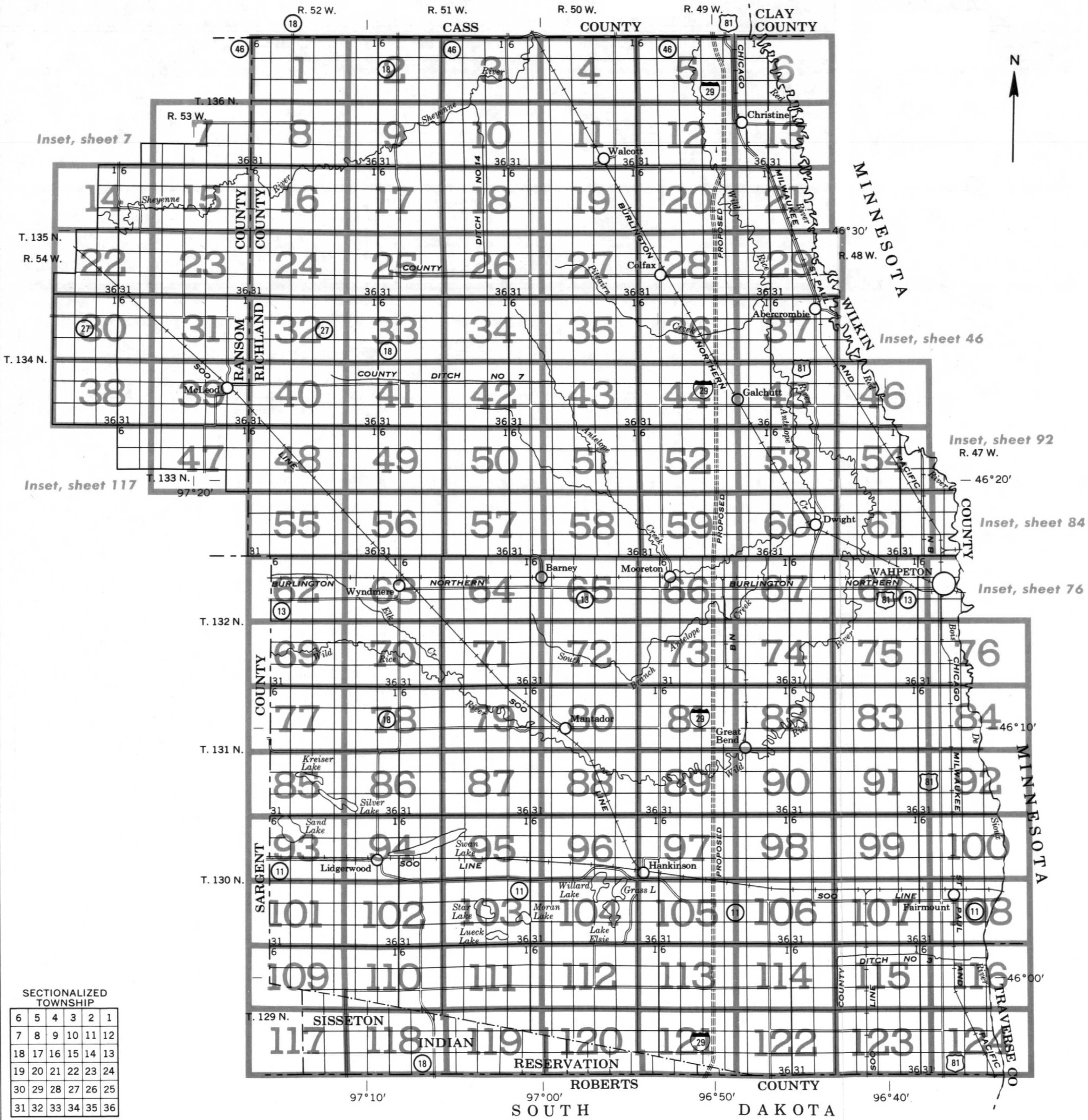
13 Antler-Doran-Tonka association: Nearly level; somewhat poorly drained and poorly drained, moderately fine textured soils formed in loamy and silty lacustrine sediments and the underlying loamy glacial till; some are shallow over lime

SHALLOW AND MODERATELY DEEP, NEARLY LEVEL TO GENTLY SLOPING, EXCESSIVELY DRAINED AND WELL DRAINED SOILS THAT ARE LESS THAN 36 INCHES DEEP TO COARSE SAND AND GRAVEL; ON BEACH RIDGES

14 Fordville-Renshaw association: Nearly level to gently sloping, well drained and excessively drained, medium-textured soils formed in loamy alluvium

*Texture is that of the surface layer of the major soils in each soil association.

Compiled 1974

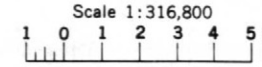


INDEX TO MAP SHEETS

RICHLAND COUNTY, AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA

Scale 1:316,800

1 0 1 2 3 4 5 Miles



SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

SOIL LEGEND

The first capital letter is the initial one of the soil name. The lowercase letter that follows separates mapping units having names that begin with the same letter, except that it does not separate sloping and eroded phases. A second capital letter, B, C, D, or E, shows the slope. Most symbols without a slope letter are for soils that are nearly level, except that the Serden-Stabilized dune land complex has a considerable range of slope. A final number, 2, in a symbol shows that the soil is eroded.

SYMBOL	NAME
Af	Aastad-Forman loams
Ag	Aberdeen fine sandy loam
Ah	Aberdeen silt loam
Ak	Aberdeen-Galchutt silty clay loams
Ao	Aberdeen-Ryan silty clay loams
Ar	Antler silty clay loam
As	Antler-Tonka silty clay loams
At	Arveson-Fossum fine sandy loams
Au	Arveson and Fossum loams
Av	Arveson and Fossum loams, very wet
Aw	Arvilla fine sandy loam
BbD	Barnes-Buse loams, hilly
BbD2	Barnes-Buse loams, hilly, eroded
BcD	Barnes-Buse-Langhei loams, hilly
BdB	Barnes-Svea loams, undulating
Bf	Bearden silty clay loam
Bg	Bearden and Glyndon silt loams, moderately deep over clay
Bo	Borup loam
Br	Borup silt loam, very wet
Ca	Cashel silty clay
Co	Colvin silty clay loam
DkB	Dickey-Towner fine sandy loams, undulating
Do	Doran clay loam
Dp	Doran-Perella clay loams
Dt	Doran-Tonka silty clay loams
Dv	Dovray silty clay
EeC	Eckman-Zell silt loams, rolling
EmB	Egeland and Maddock fine sandy loams, undulating
En	Embden-Tiffany fine sandy loams
Et	Embden-Tiffany loams
Ey	Exline and Ryan soils
Fa	Fairdale silt loam
Fb	Fairdale silt loam, channeled
Fd	Fairdale silty clay loam
Fe	Fargo silty clay loam
Ff	Fargo silty clay
Fg	Fargo silty clay, depressional
FhB	Fargo silty clay, gently sloping
Fk	Fargo silty clay, till substratum
Fm	Fargo-Enloe silty clay loams
Fn	Fargo-Enloe complex, till substratum
Fo	Fargo-Hegne silty clays
Fp	Fargo-Hegne silty clays, till substratum
Fr	Fargo-Ryan silty clay loams

SYMBOL	NAME
Fs	Fargo-Ryan silty clays
Ft	Fordville-Renshaw loams
FuB	Forman-Aastad loams, undulating
FuB2	Forman-Aastad loams, undulating, eroded
FvC	Forman-Buse loams, rolling
FvC2	Forman-Buse loams, rolling, eroded
FwB	Forman-Peever clay loams, undulating
Fx	Fossum fine sandy loam .
Ga	Galchutt silt loam
Gc	Galchutt-Enloe-Fargo complex
Gd	Galchutt-Overly silt loams
Ge	Gardena silt loam
GfB	Gardena-Eckman silt loams, undulating
Gh	Gardena and Embden loams
Gk	Gilby silt loam
Gm	Gilby silt loam, moderately saline
Gn	Gilby and Hamerly loams
Go	Glyndon silt loam
Gr	Glyndon-Tiffany very fine sandy loams
Gt	Glyndon-Tiffany loams, moderately deep over clay
Gu	Glyndon and Wyndmere loams
Gw	Grano clay
Ha	Hamar loamy fine sand
Hb	Hamar loamy fine sand, moderately deep over clay
Hc	Hamar fine sandy loam
He	Hamar fine sandy loam, moderately deep over clay
Hf	Hamar-Ulen loamy fine sands
Hg	Hamar-Ulen fine sandy loams
Hh	Hamerly loam
Hk	Hecla loamy fine sand, loamy substratum
Hm	Hecla-Hamar loamy fine sands
Hm3	Hecla-Hamar loamy fine sands, severely eroded
Hn	Hecla-Hamar fine sandy loams
Ho	Hecla-Hamar-Arveson complex
Hr	Hecla-Maddock loamy sands
Hs	Hecla-Maddock sandy loams
Kr	Kratka fine sandy loam
La	LaDelle silty clay loam
Lb	LaDelle and Wahpeton soils, channeled
Lm	Lamoure silty clay loam
Lp	LaPrairie silt loam
MdC	Maddock loamy fine sand, rolling
MhB	Maddock-Hecla loamy fine sands, undulating
MlB	Maddock-Hecla-Hamar loamy fine sands, undulating
Mr	Marsh

SYMBOL	NAME
NuC	Nutley silty clay, rolling
Oc	Overly silty clay loam
Od	Overly-Bearden silt loams, moderately saline
Oe	Overly-Bearden silty clay loams, moderately saline
OlB	Overly-Beotia silty clay loams, undulating
Pc	Parnell silty clay loam
Pd	Parnell and Tonka silty clay loams
Pe	Peat
Pf	Peever-Forman clay loams
Pr	Perella loam, moderately deep over clay
Ps	Perella silty clay loam, moderately deep over clay
Ro	Roliss clay loam
Ry	Ryan-Fargo complex
Sd	Serden loamy fine sand
Se	Serden-Stabilized dune land complex
ShB	Sioux-Renshaw complex, undulating
ShE	Sioux-Renshaw complex, hilly
Sr	Stirum-Arveson loams
St	Strongly saline land
Su	Svea loam
SvB	Svea-Buse loams, undulating
SvC	Svea-Buse loams, rolling
Sw	Svea-Gardena loams
Sy	Swenoda-Wyndmere fine sandy loams
Td	Tiffany fine sandy loam
Tf	Tiffany loam
Th	Tiffany loam, moderately deep over clay
Tk	Tonka silt loam
To	Towner loamy fine sand
Tw	Towner and Swenoda fine sandy loams
Un	Ulen fine sandy loam
Va	Vallers clay loam
Ve	Venlo fine sandy loam
Wa	Wahpeton silty clay
We	Wet alluvial land
Wy	Wyndmere fine sandy loam
ZeD	Zell-Eckman silt loams, hilly
ZeE	Zell-Eckman silt loams, steep

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Divided
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under

Buildings
- School
- Church

Mine and quarry

Gravel pit (G.P.)

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

Located object

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Soil survey
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
  - Unclassified

Canals and ditches

Lakes and ponds
- Perennial (water, w)
- Intermittent (int)

Spring

Well, artesian

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments
- Bedrock
- Other

Short steep slope

Prominent peak

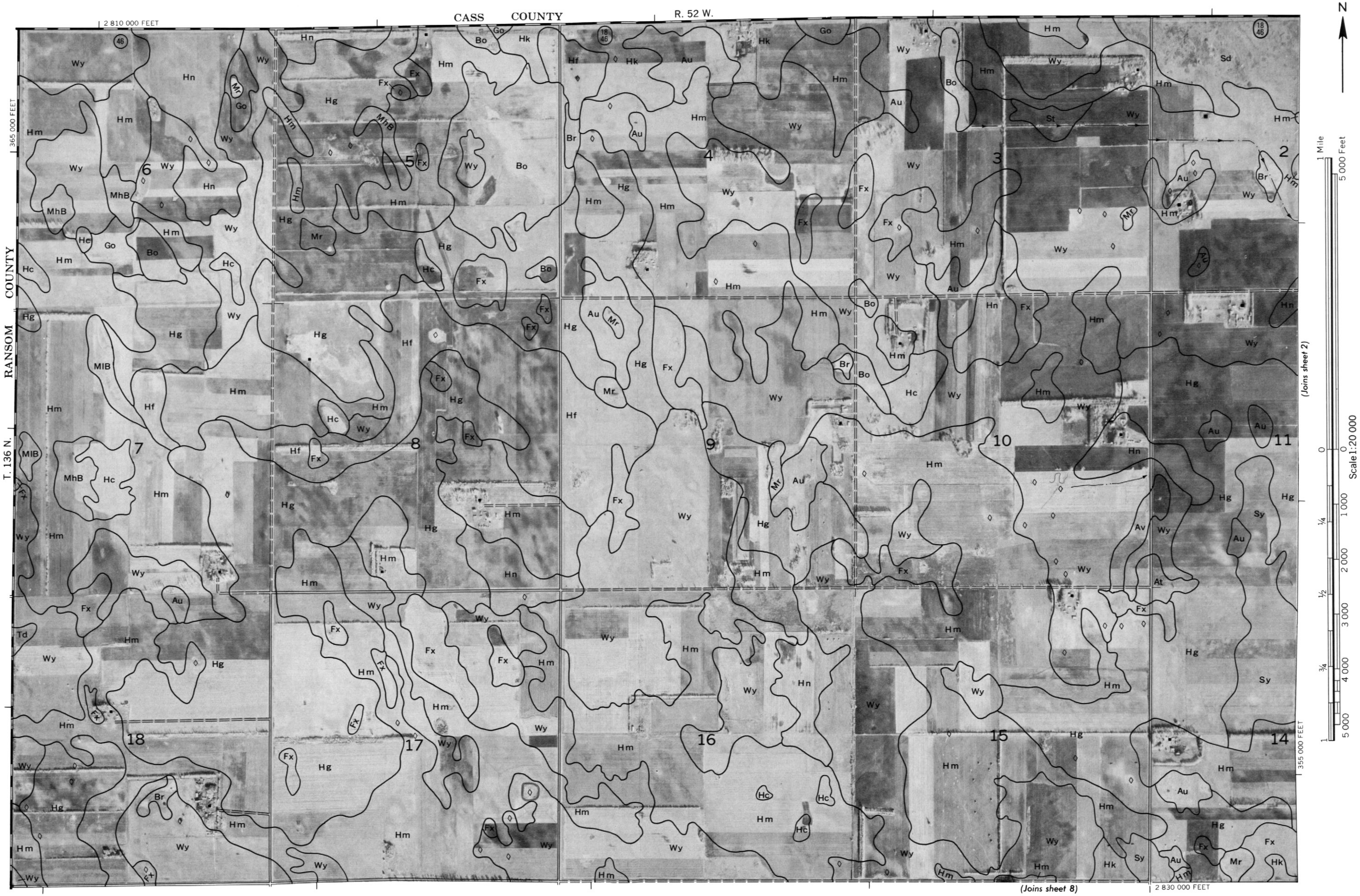
Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stoniness
  - Stony
  - Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Saline spot

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 1

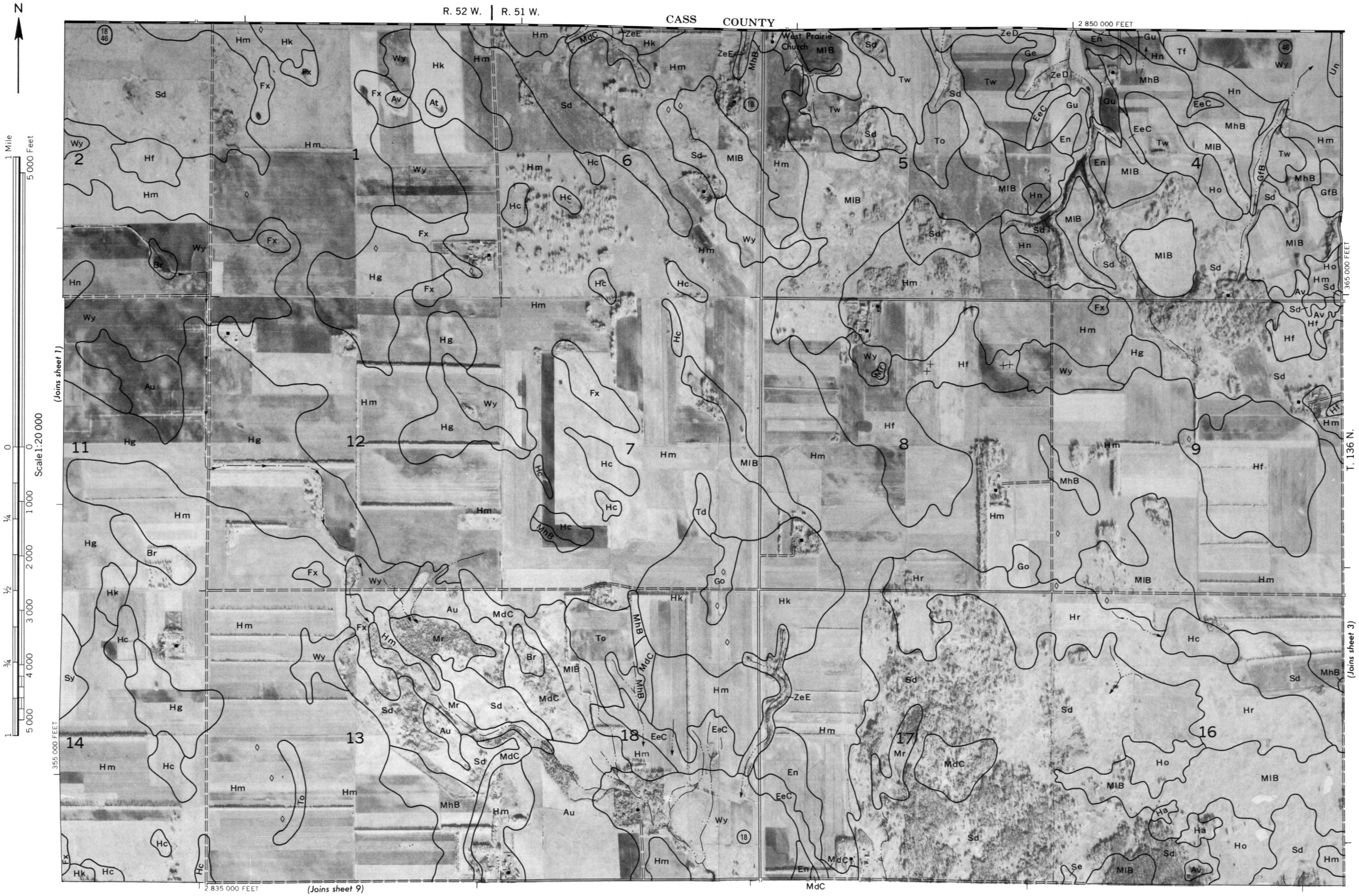
1



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 1

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 2



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 2

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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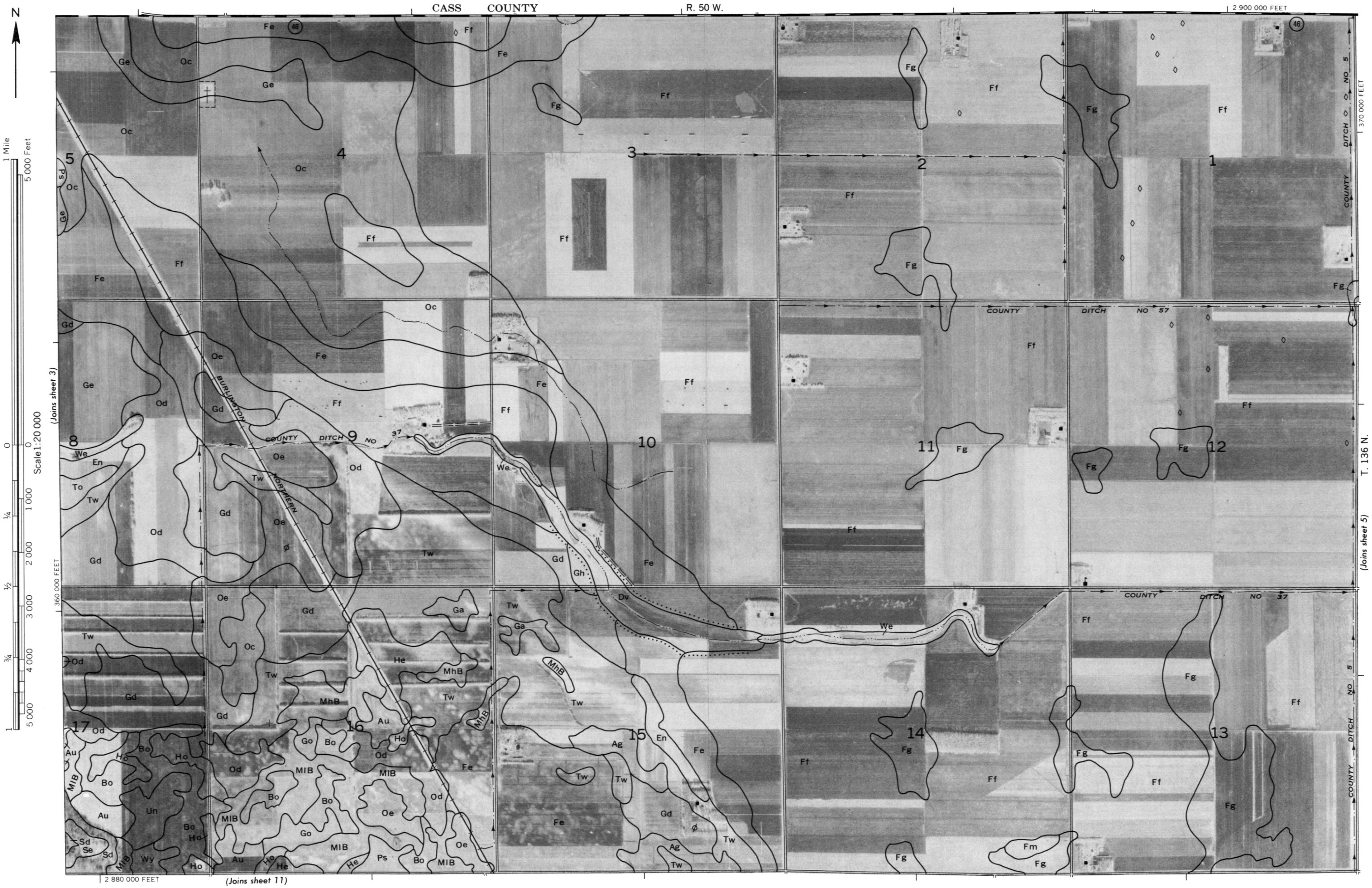
Land division corners are approximately positioned on this map.



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 4

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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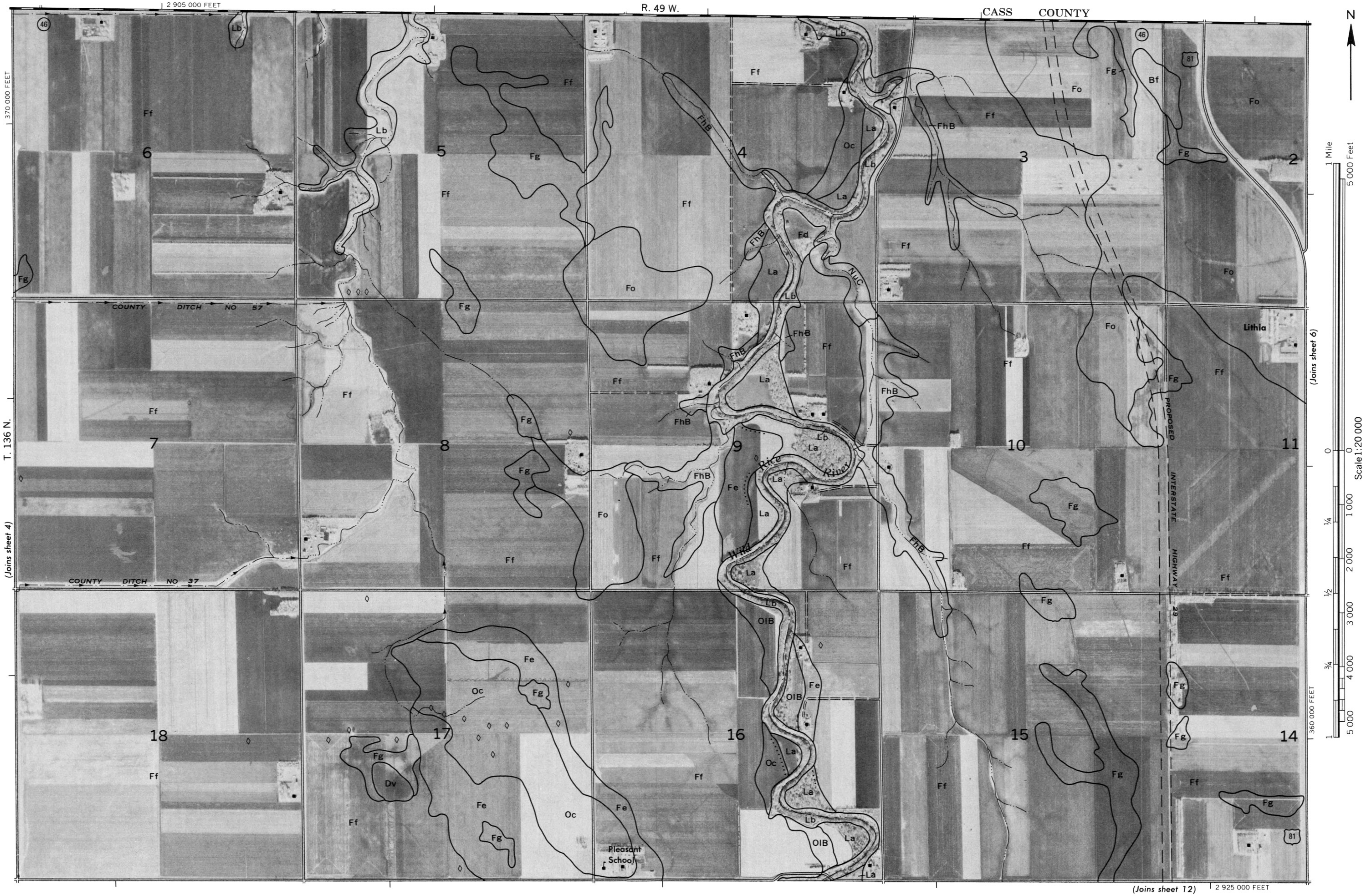
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 5

5



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
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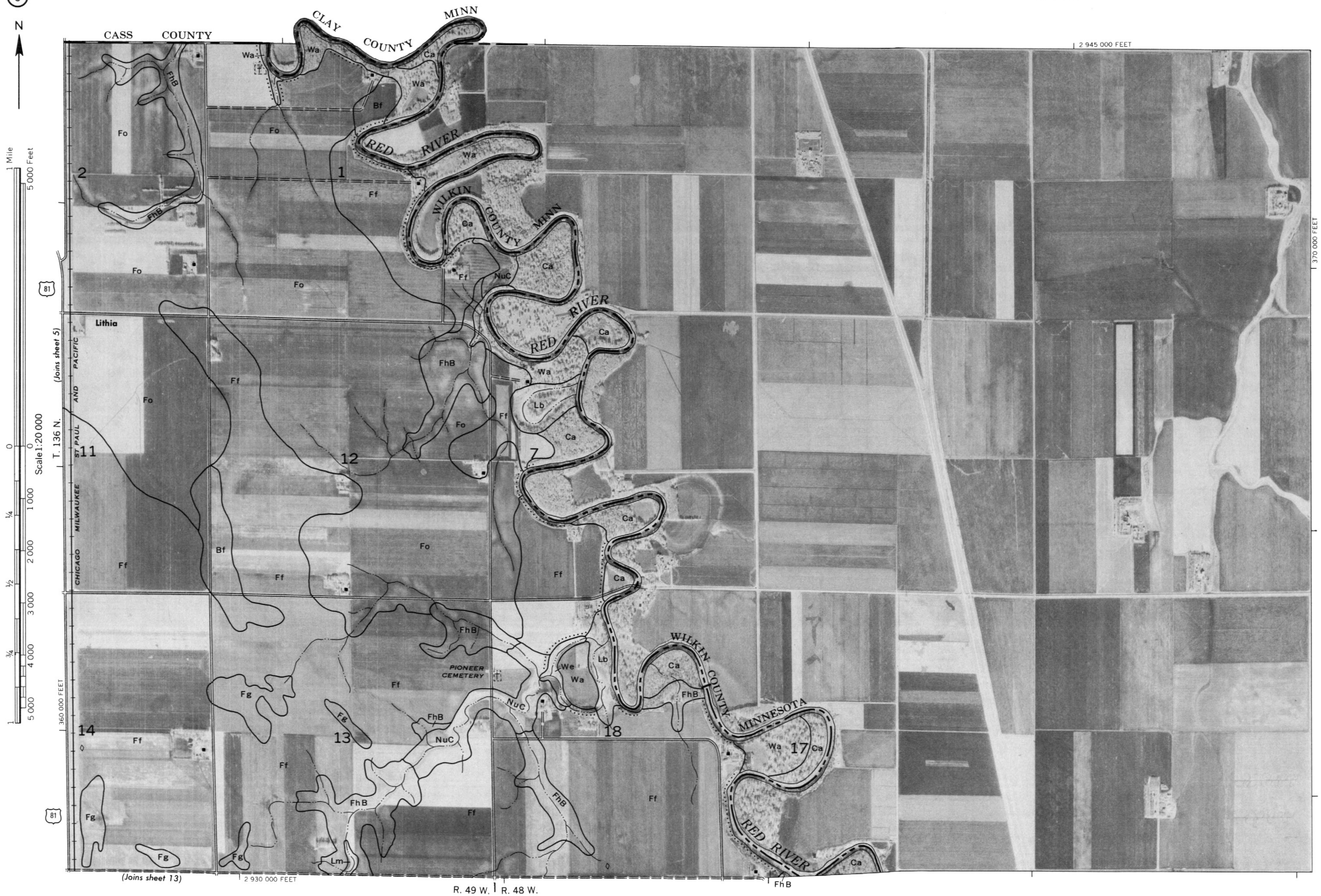
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 5

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 6

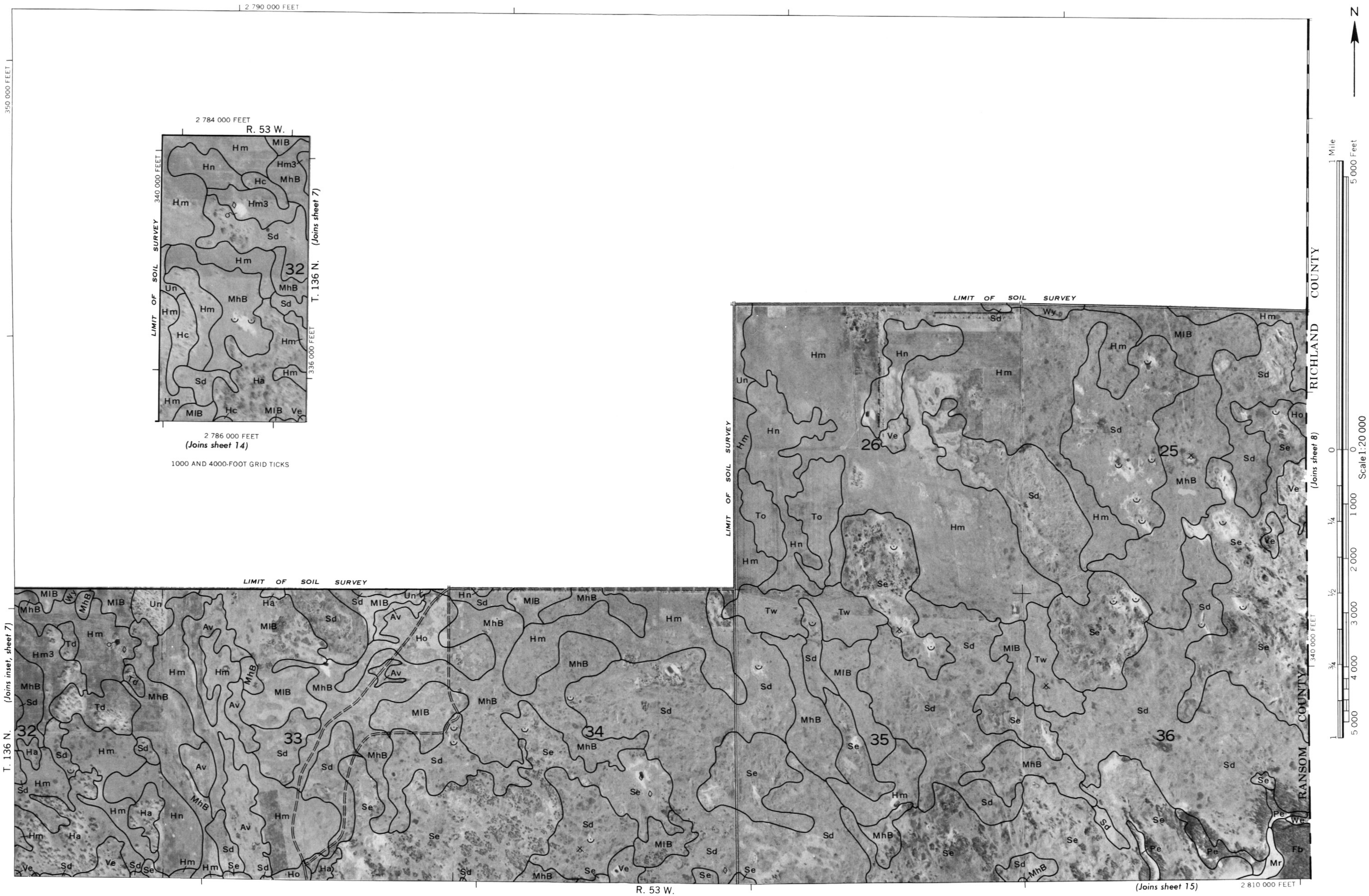


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 6

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 7

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 8

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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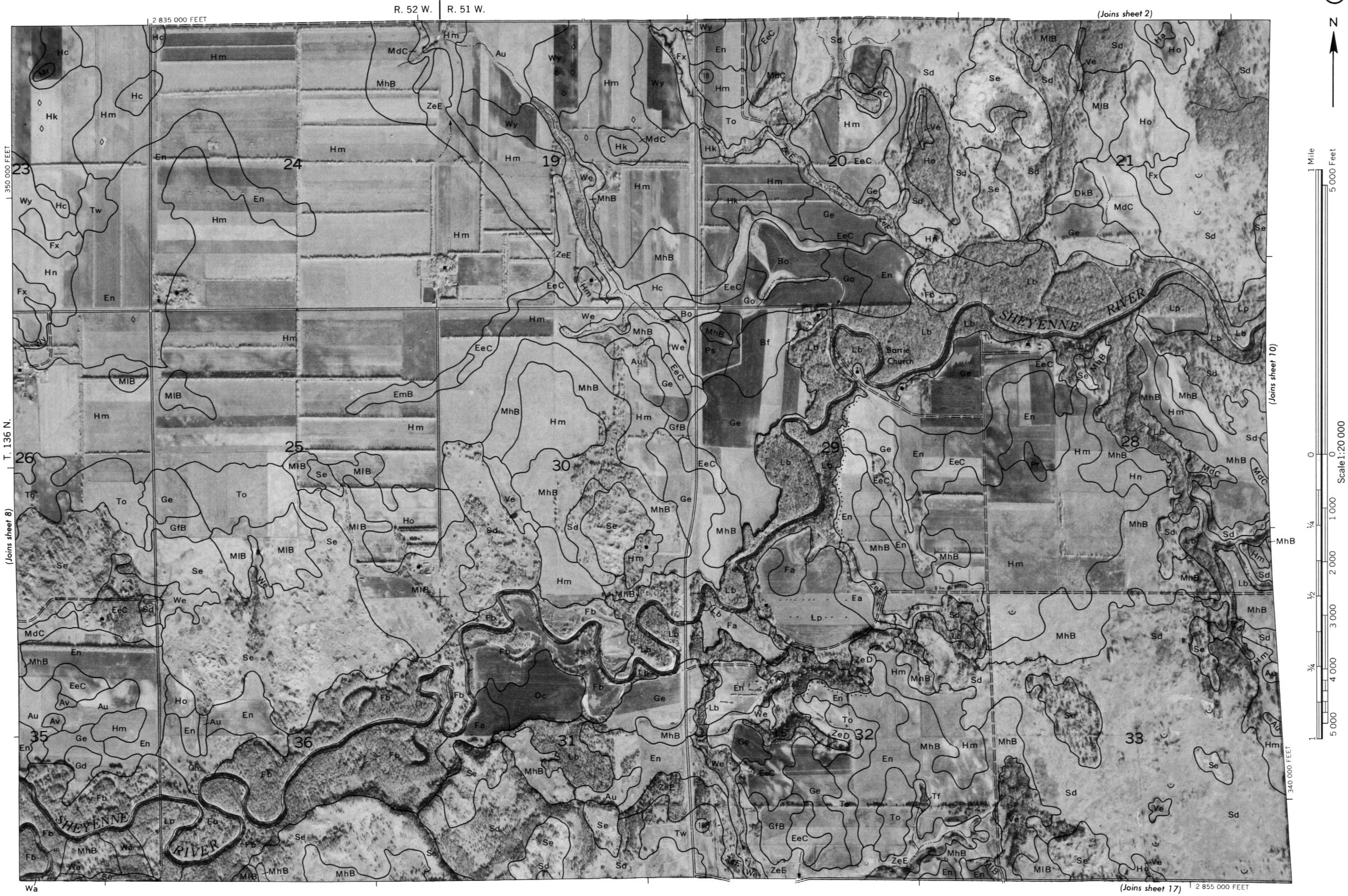

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RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 9

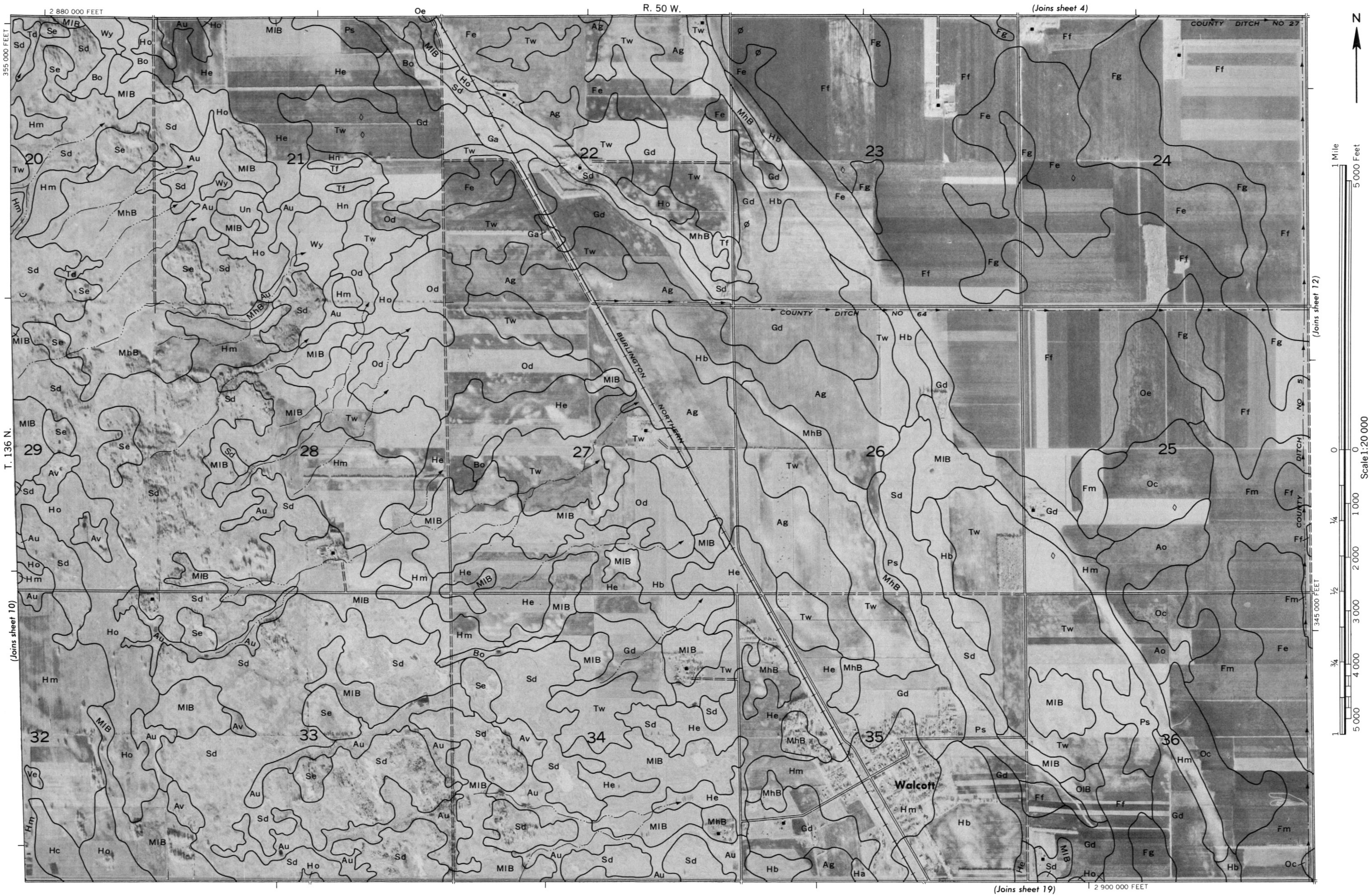
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 10

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 10

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



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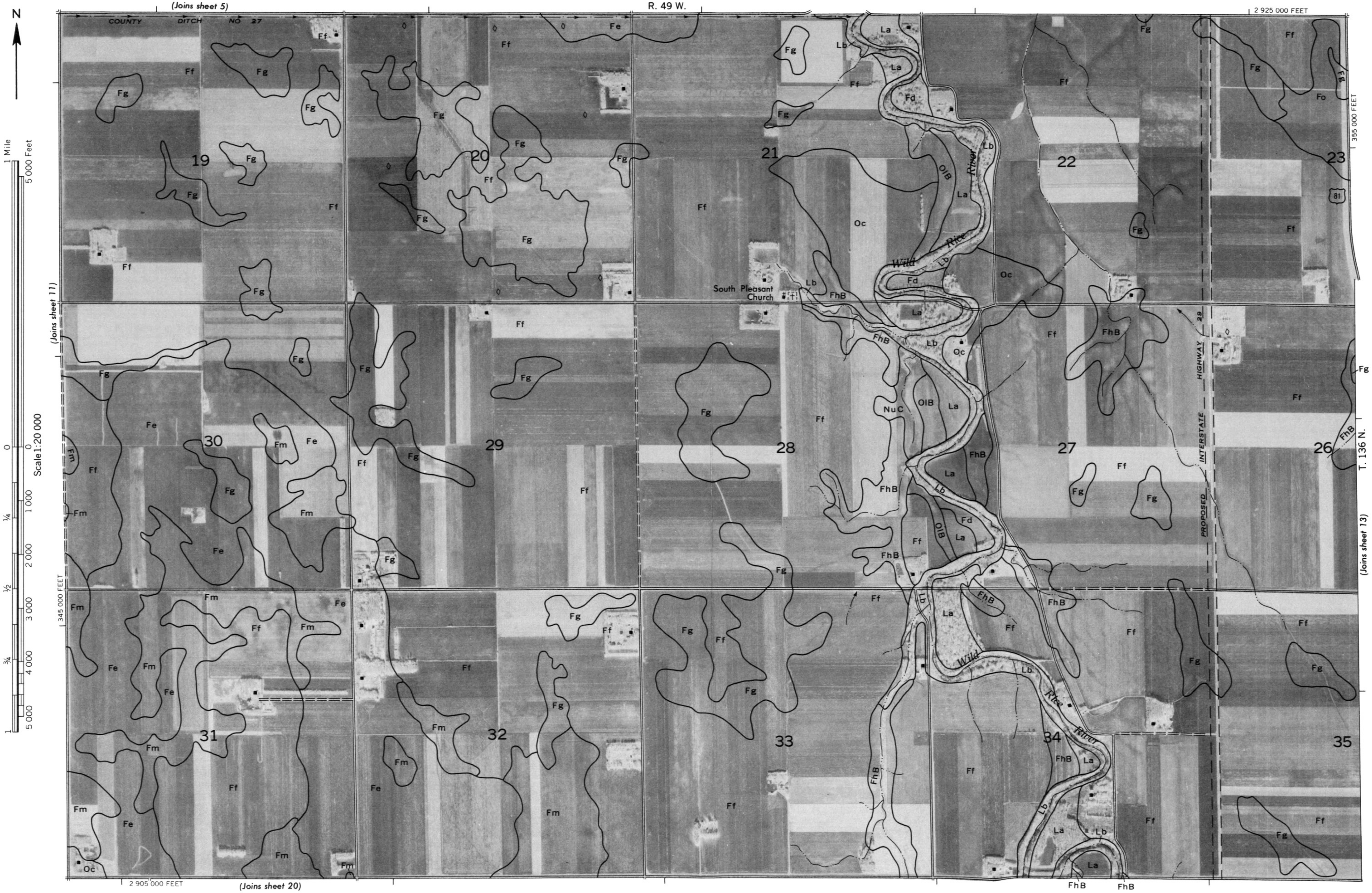
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 11

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 12



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 12

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 13

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 14

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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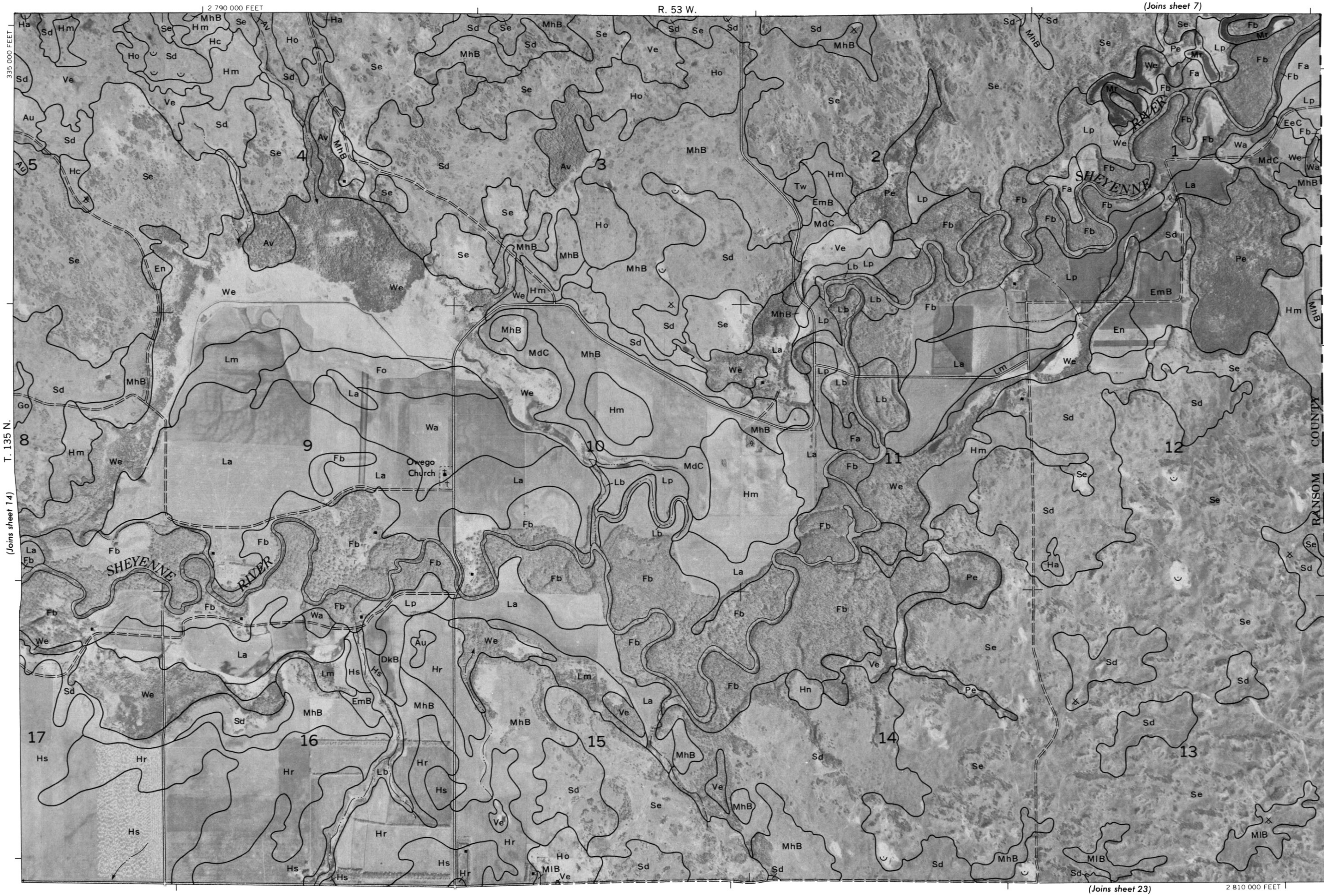
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 15



N

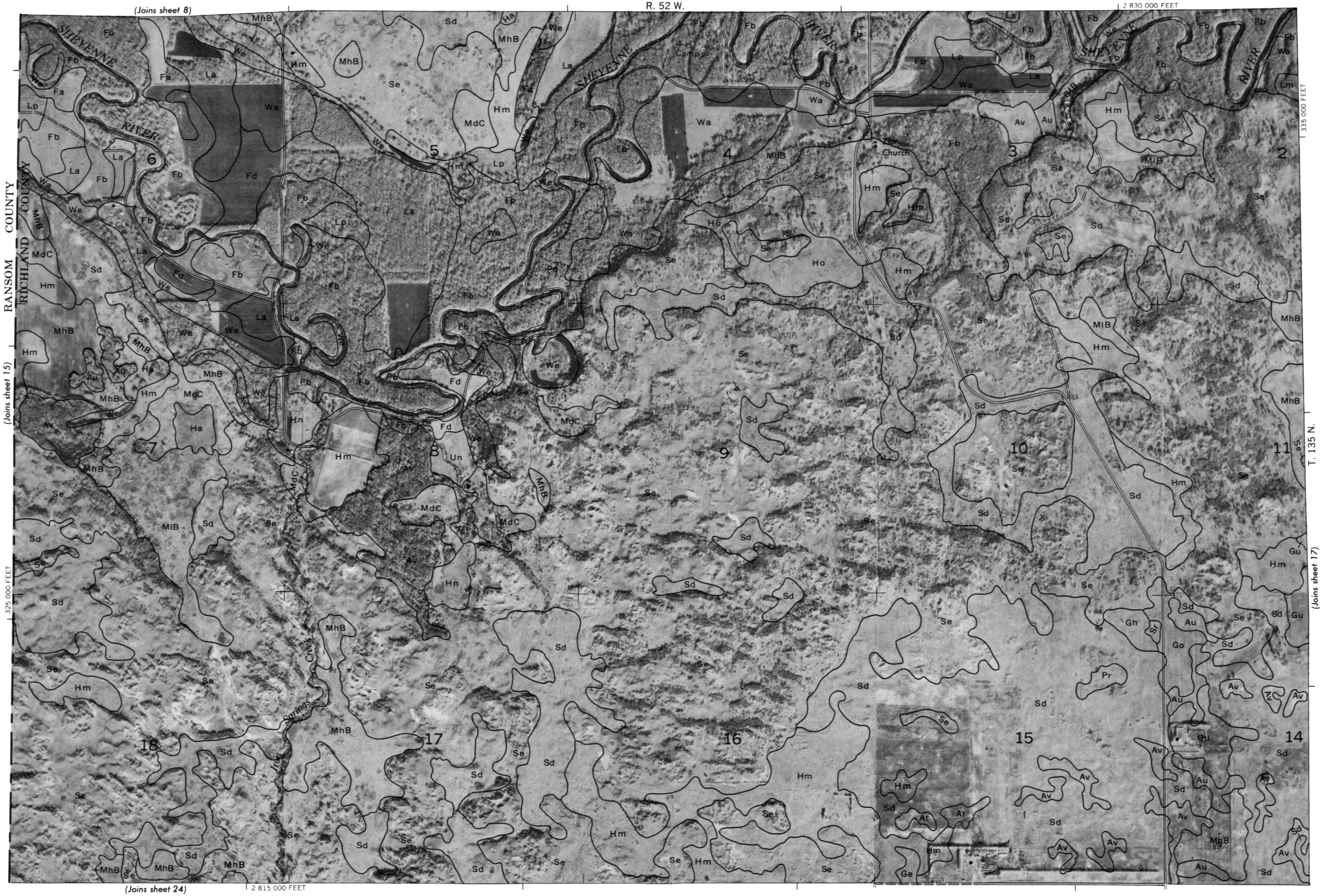
1 Mile
5 000 Feet
0
0
1/4
1 000
1/2
2 000
3 000
3/4
4 000
1
5 000
Scale 1:20 000

N

Scale 1:20 000

1 Mile ¾ ½ ¼ 0

5 000 Feet 5 000 4 000 3 000 2 000 1 000 0

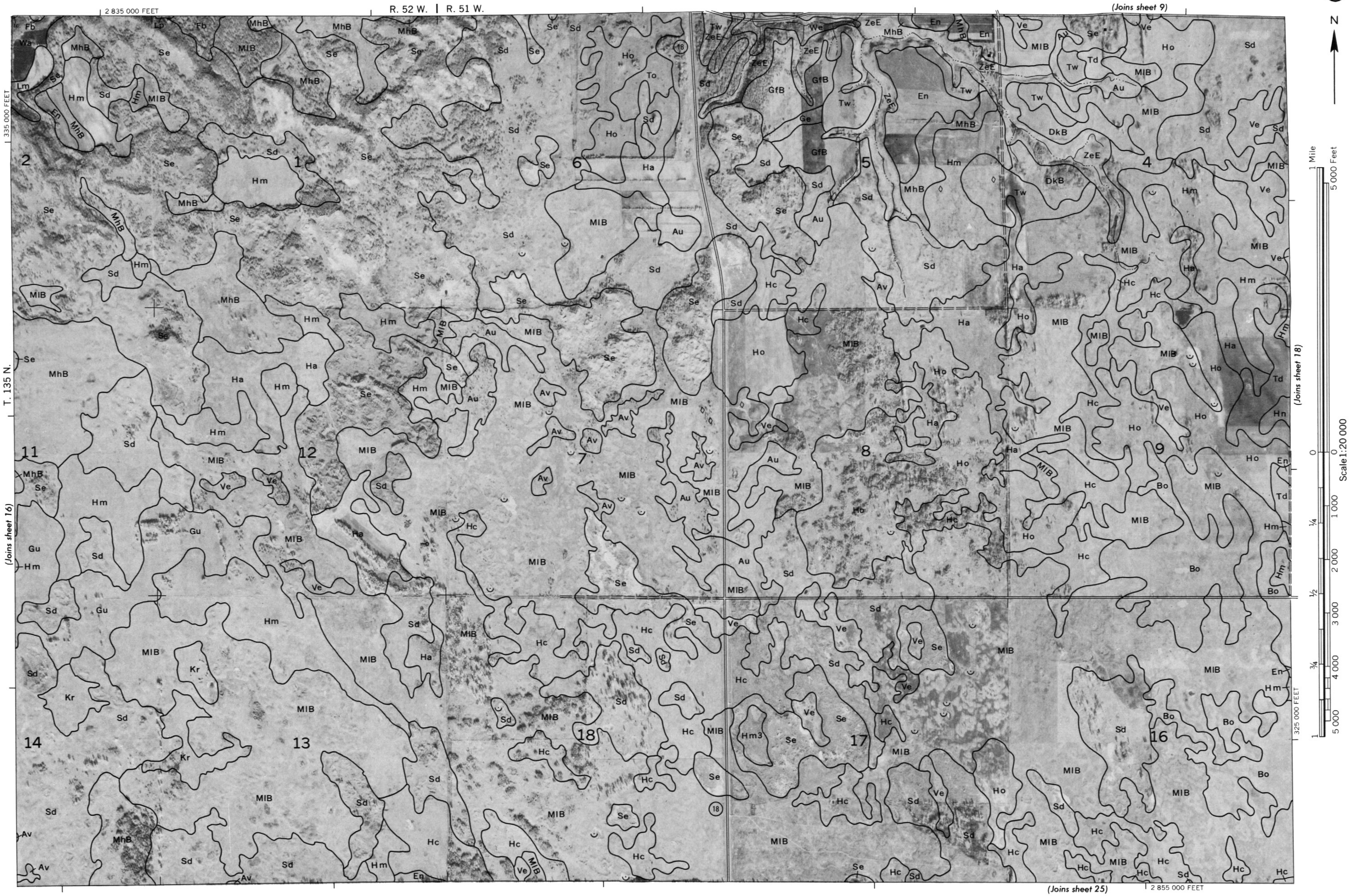


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 16

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



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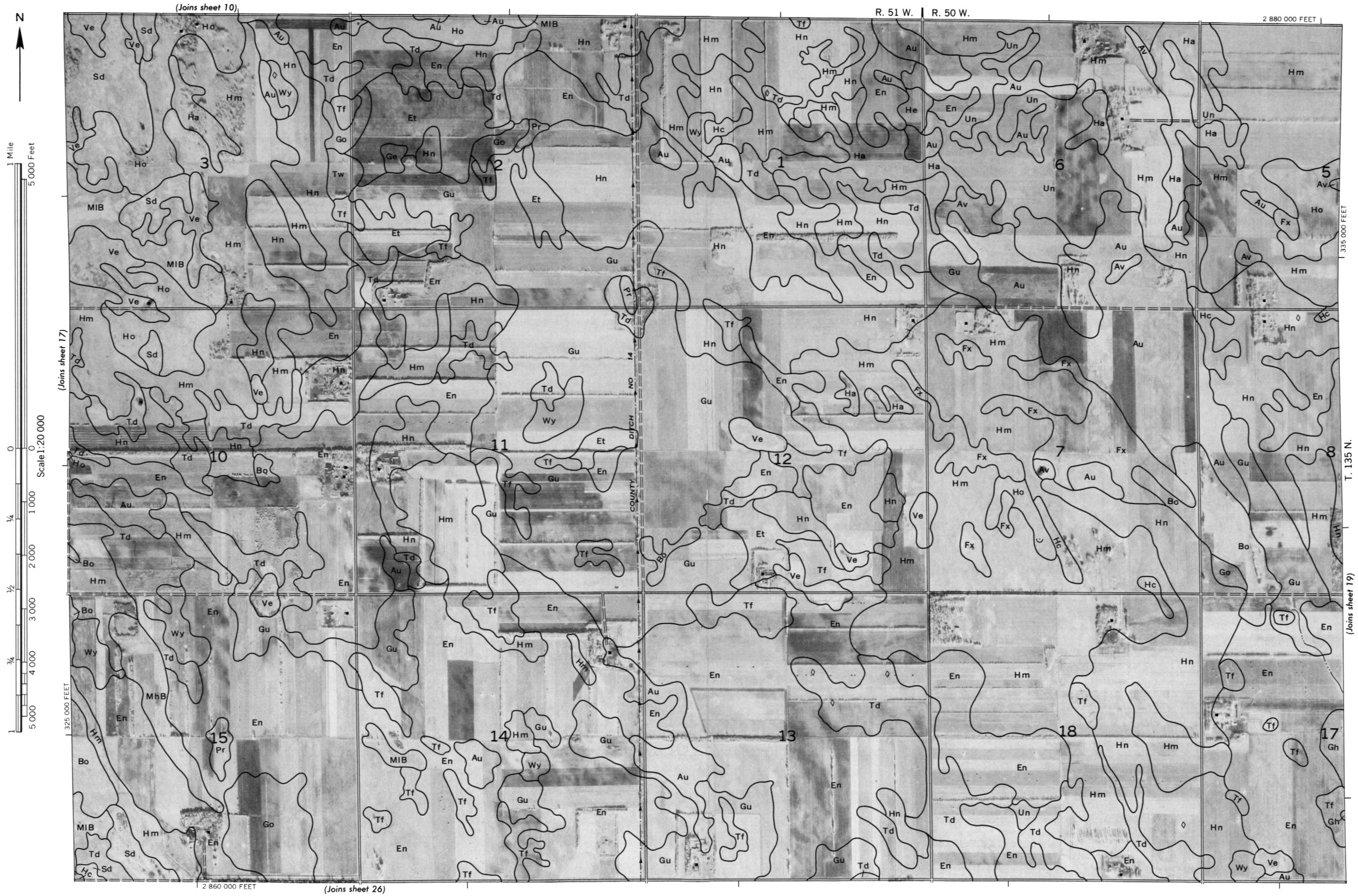
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 18



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 18

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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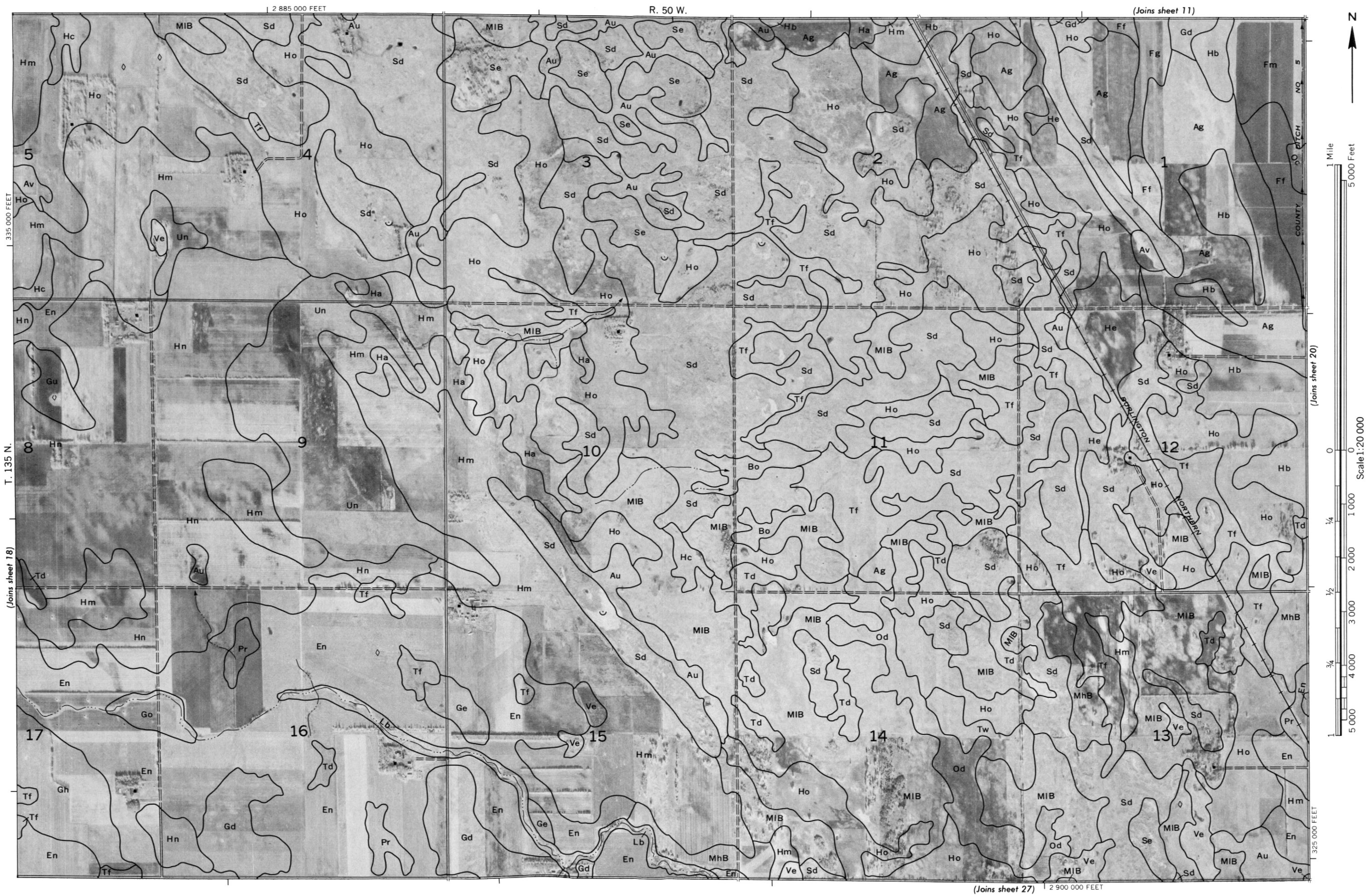
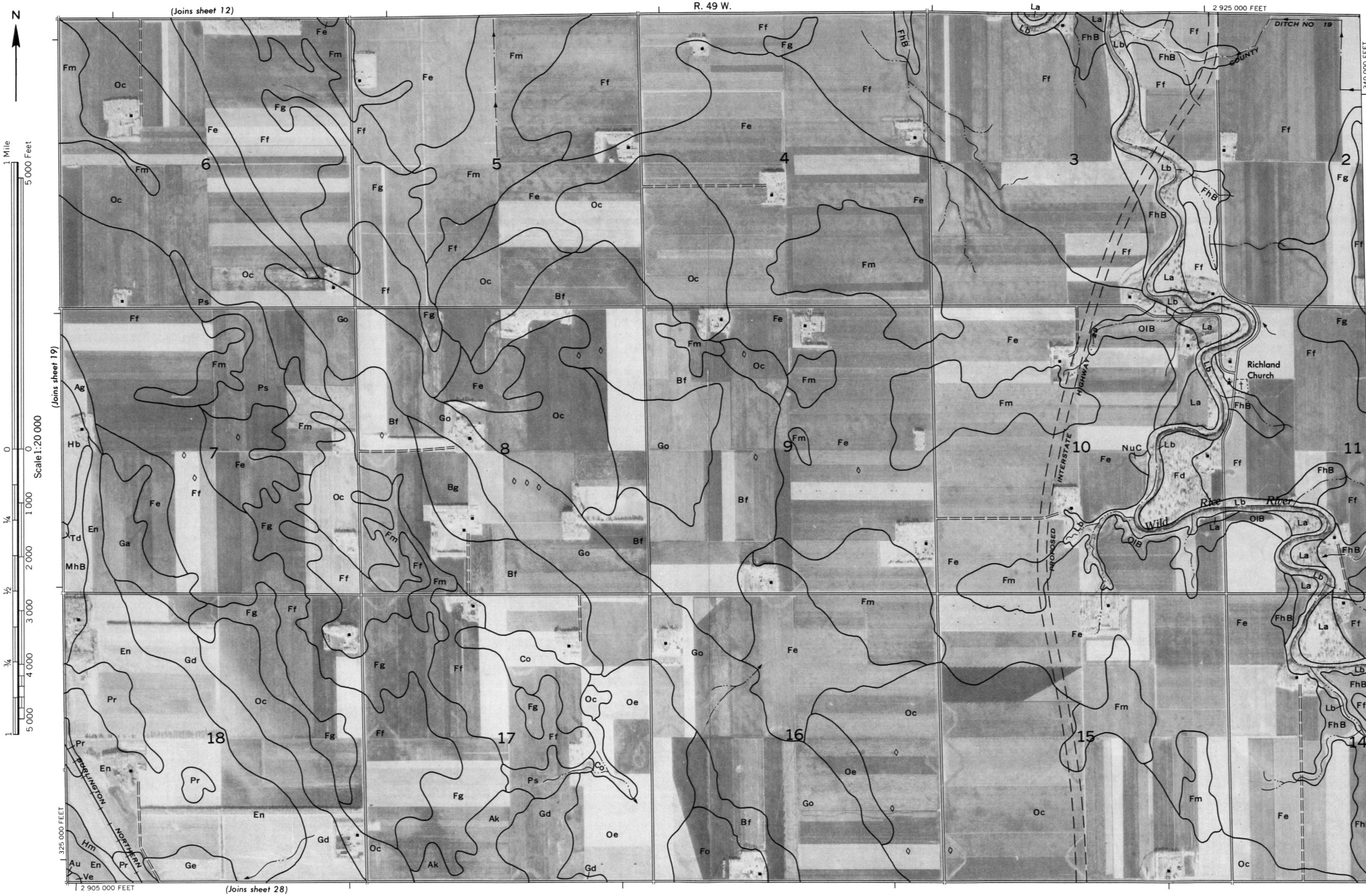
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 19



RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 20



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 20

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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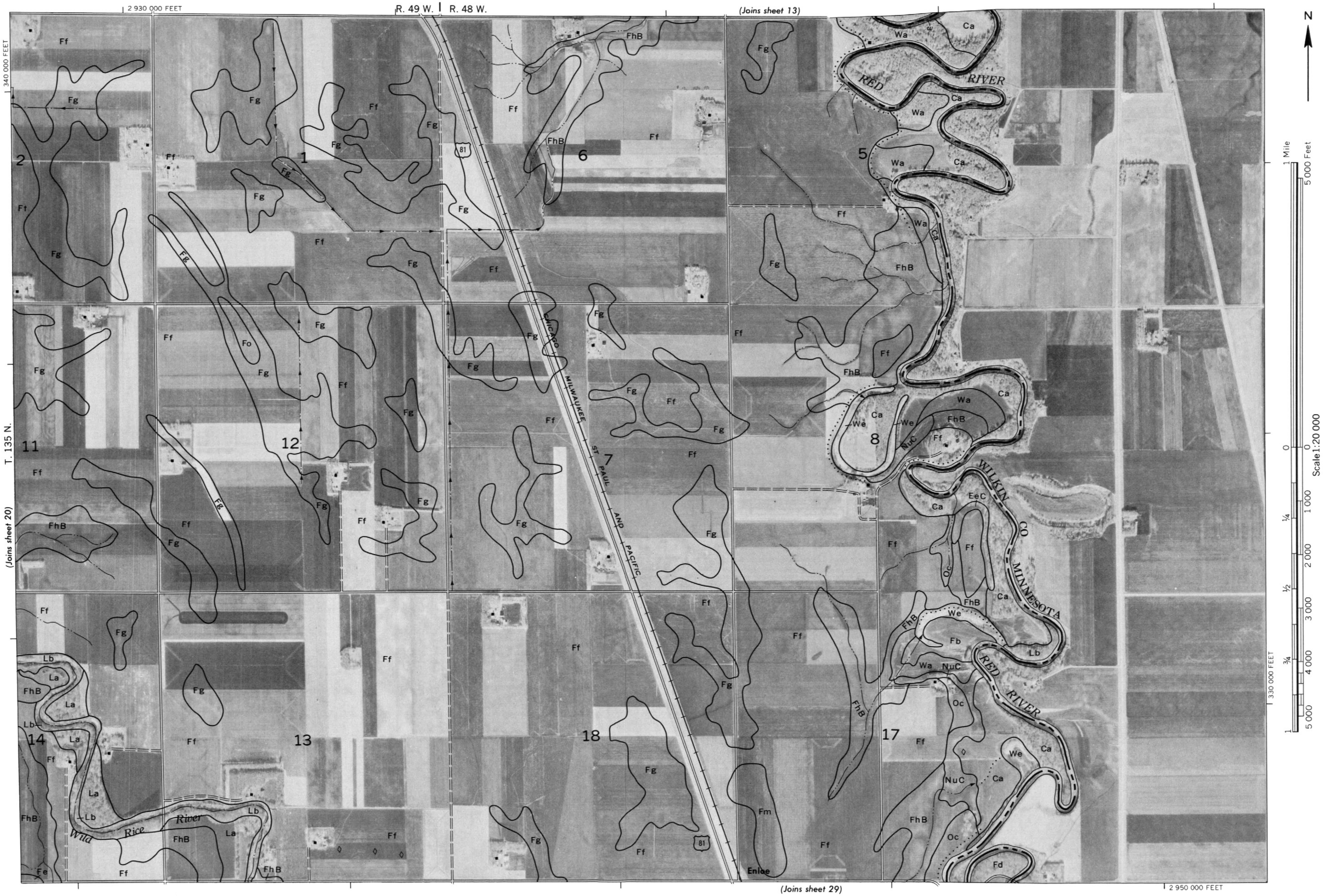
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 21



RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 22

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 22

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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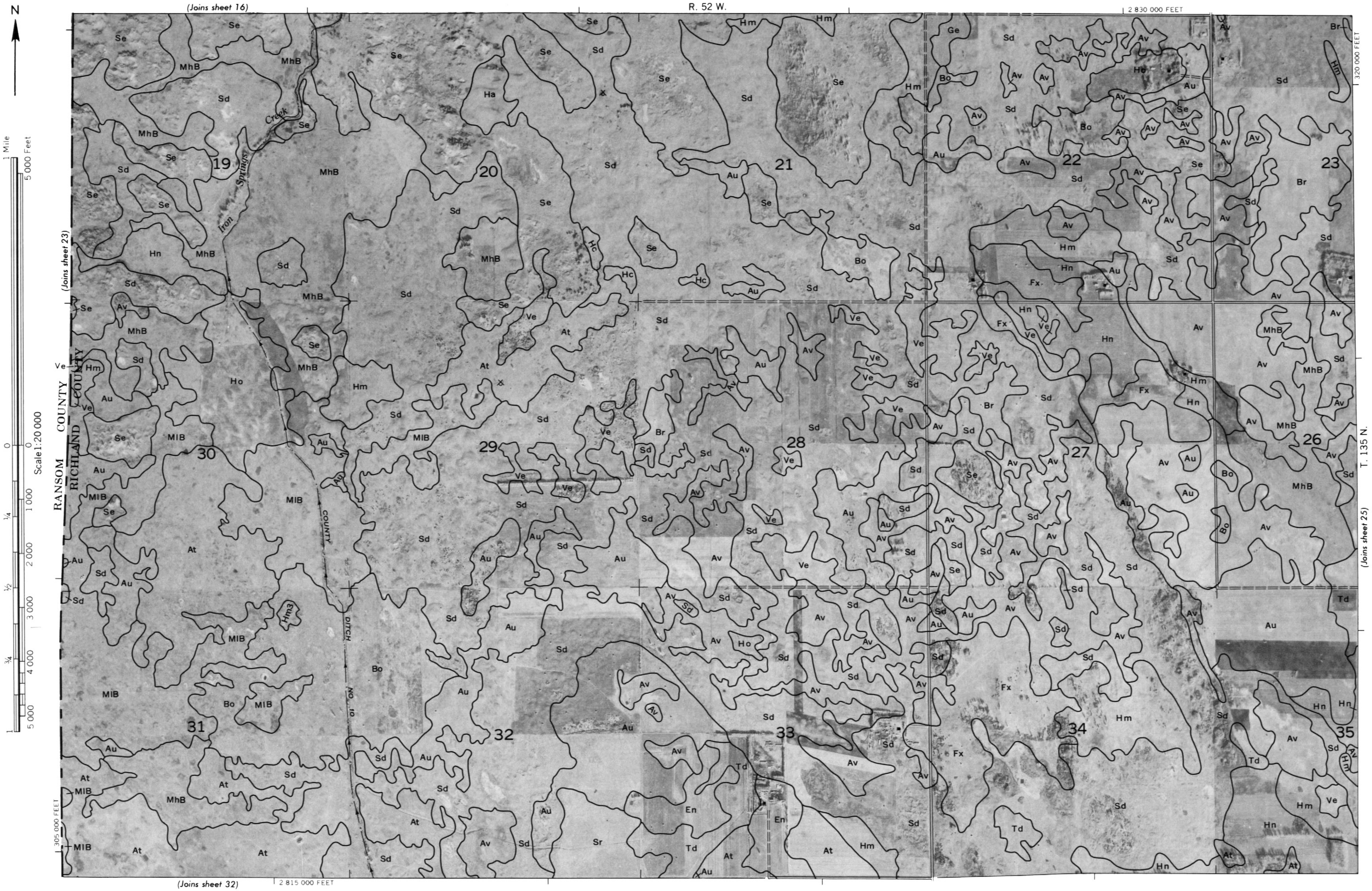
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 23

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 24



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N. D. NO. 24

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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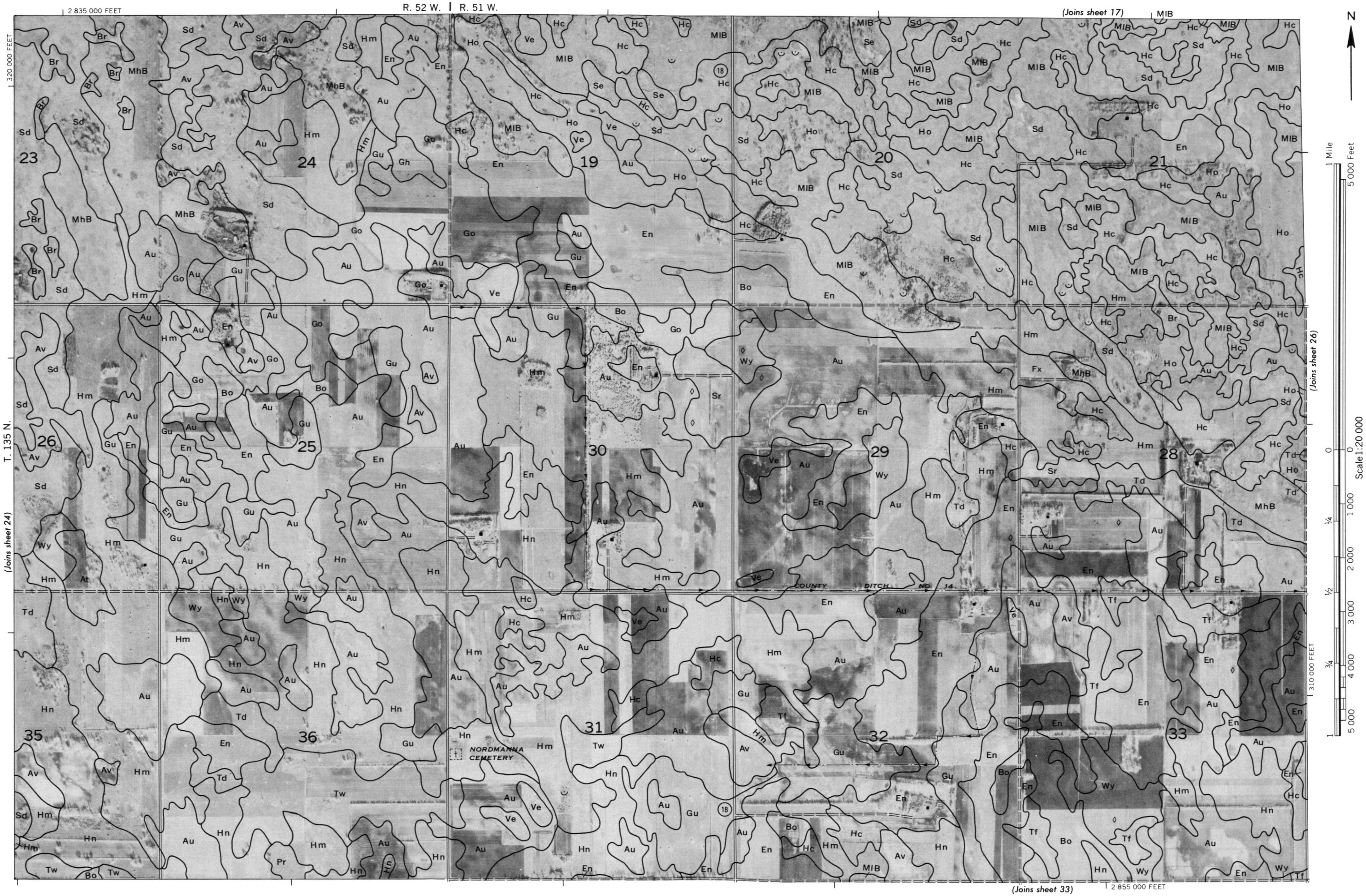

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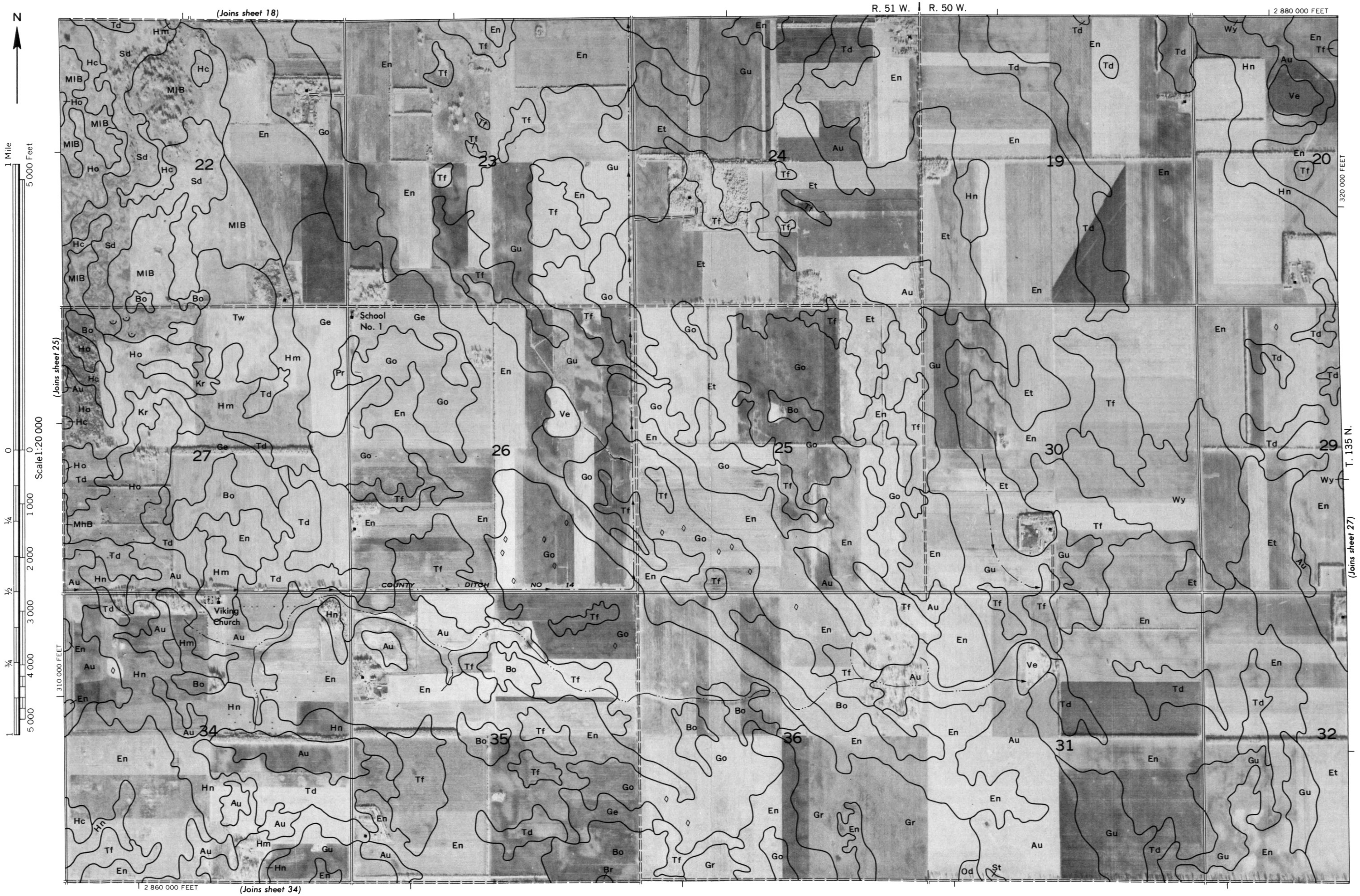
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 25

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 26

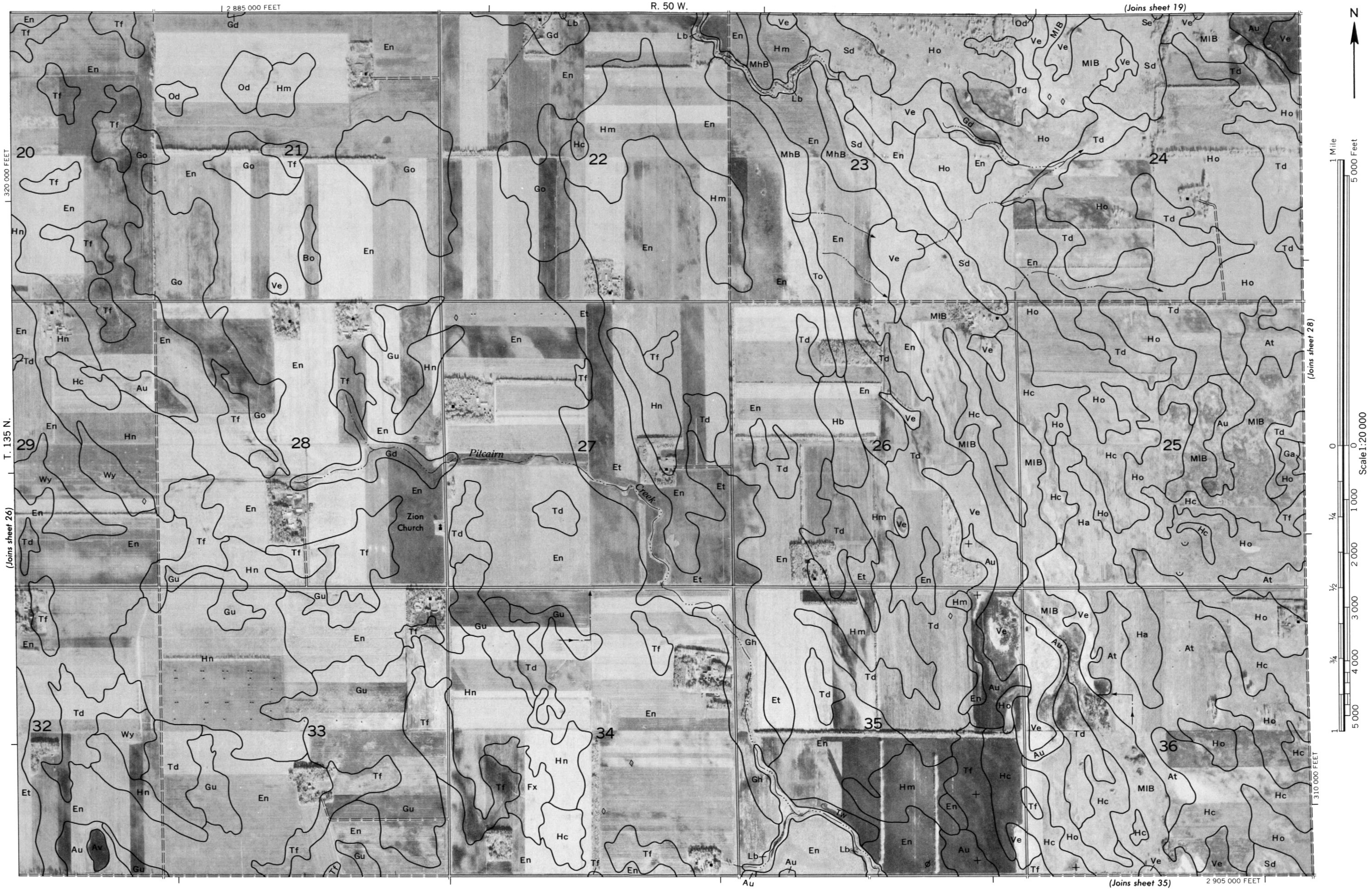


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 26

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



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Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
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RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 27

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 28

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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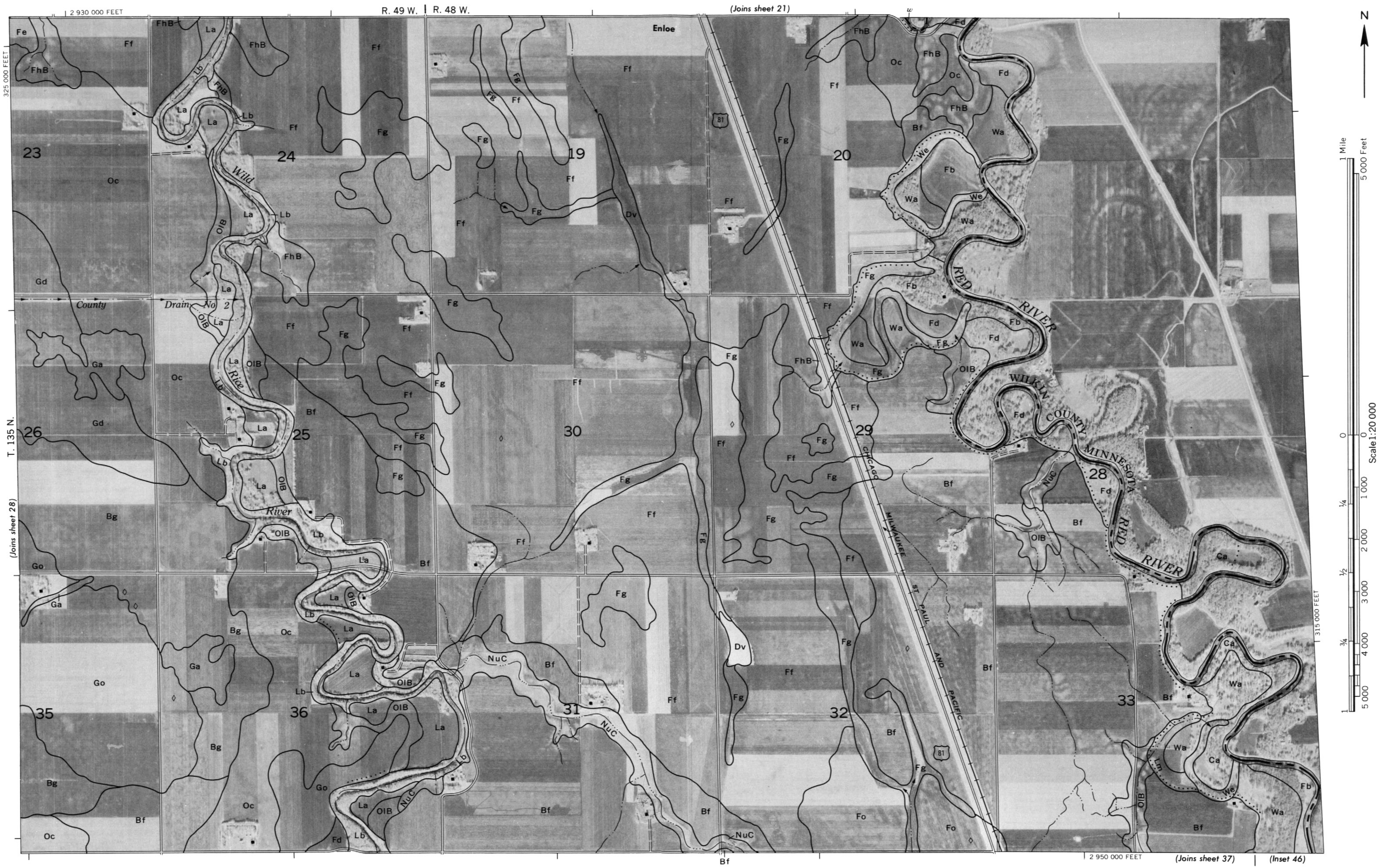


This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

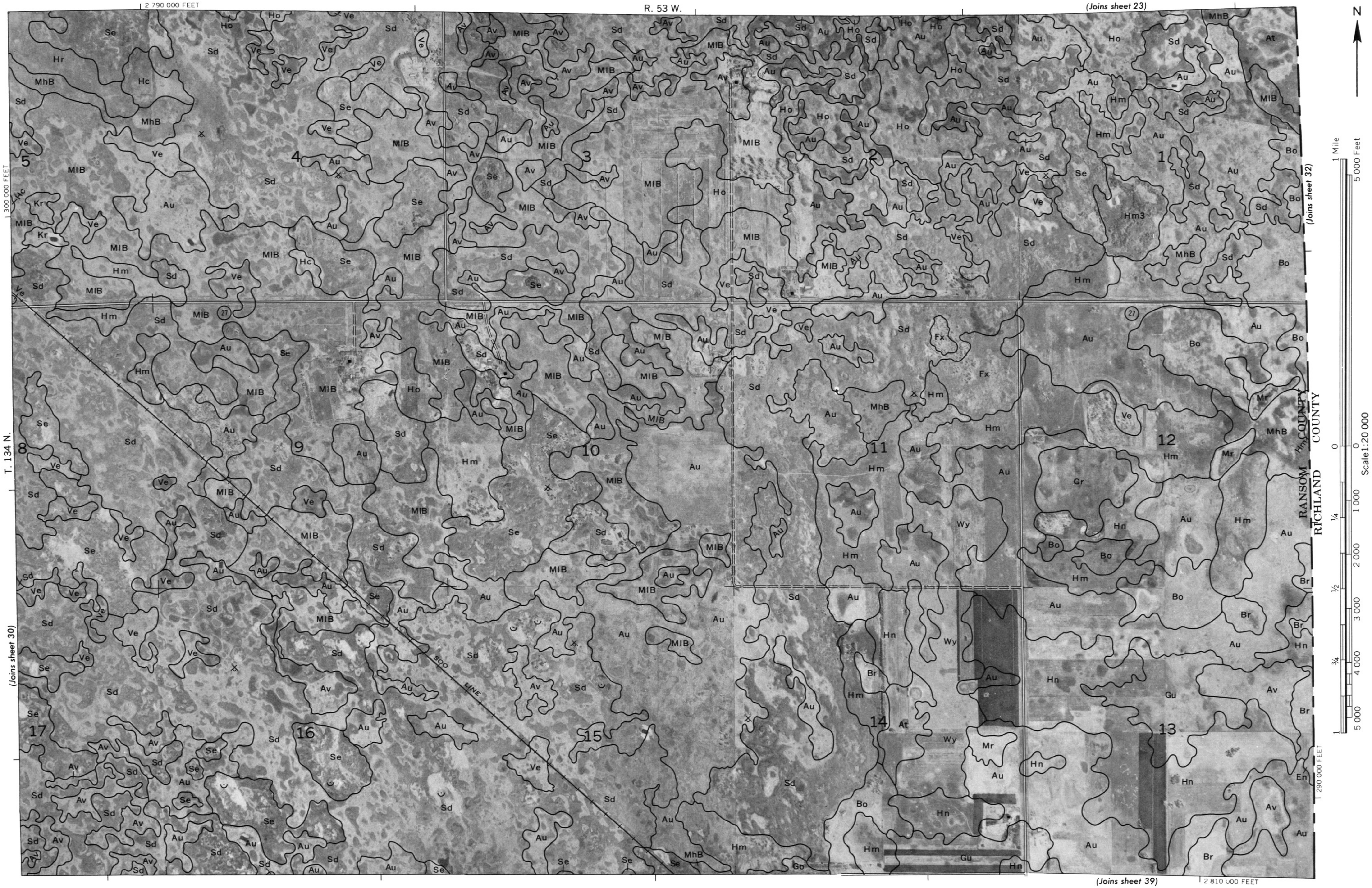
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 30

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 30

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

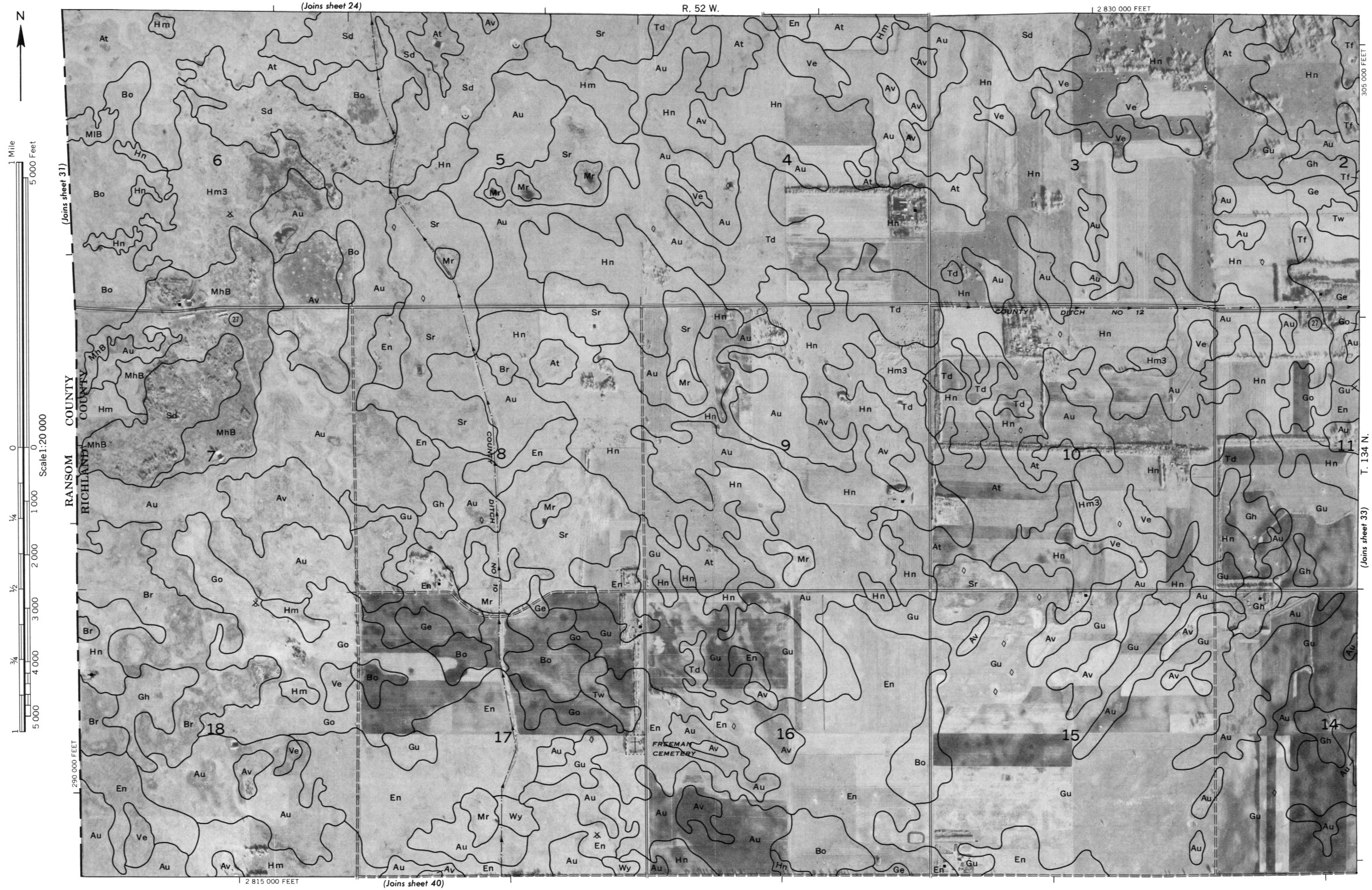
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 31

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 32

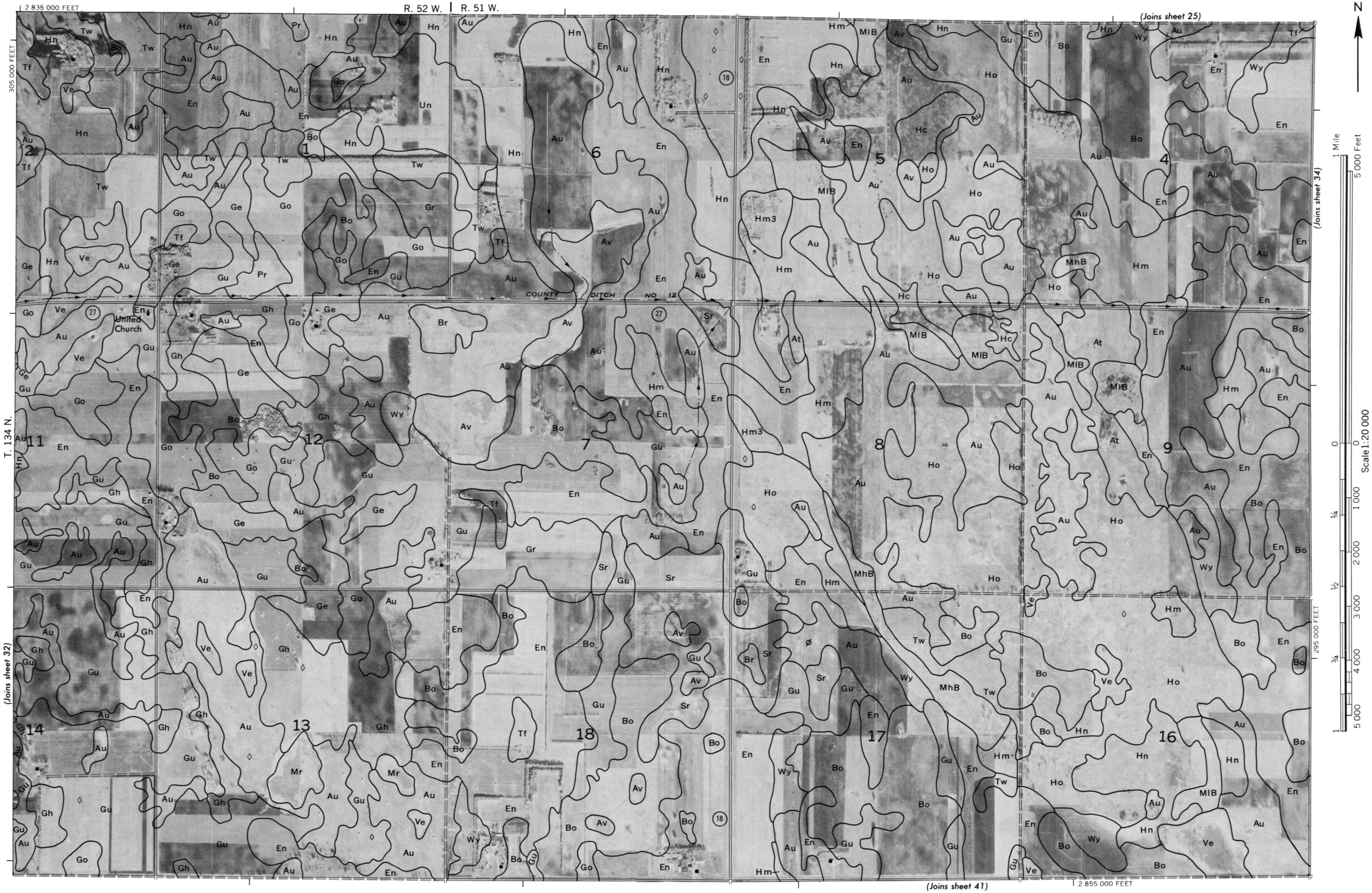


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 32

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



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Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 33

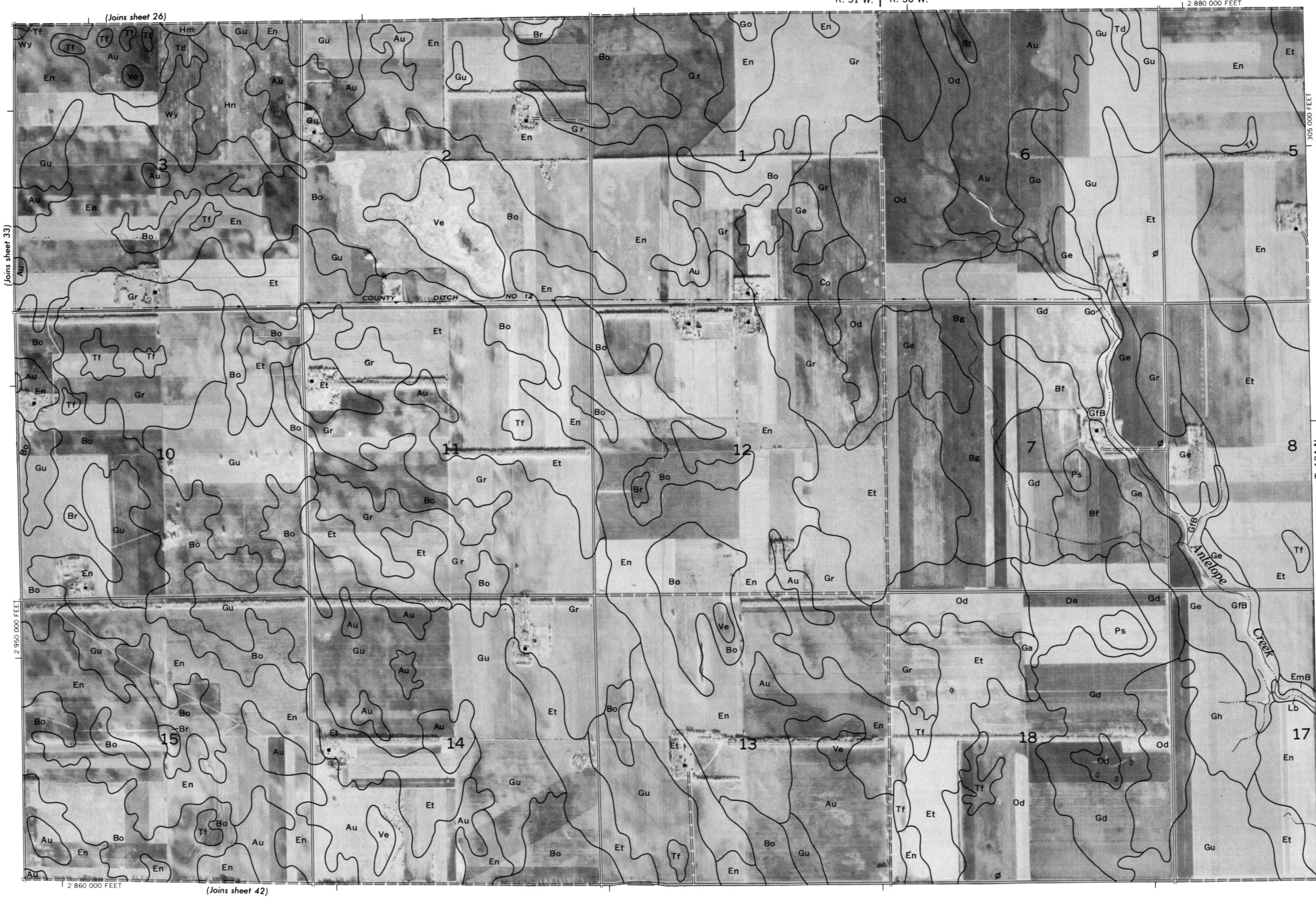
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 34

N

Scale 1:20 000

1 Mile

5 000 Feet

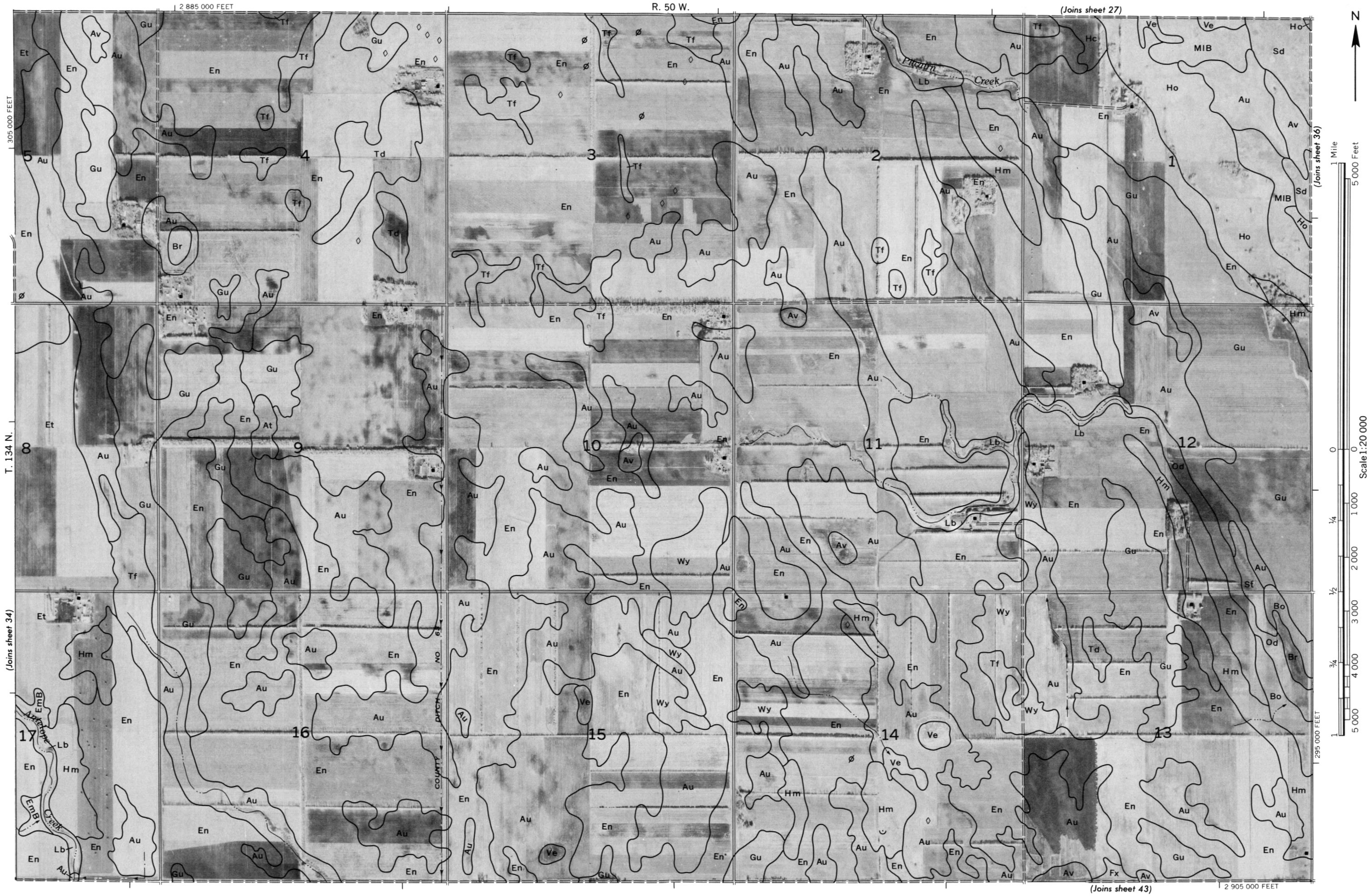


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 34

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

(36)

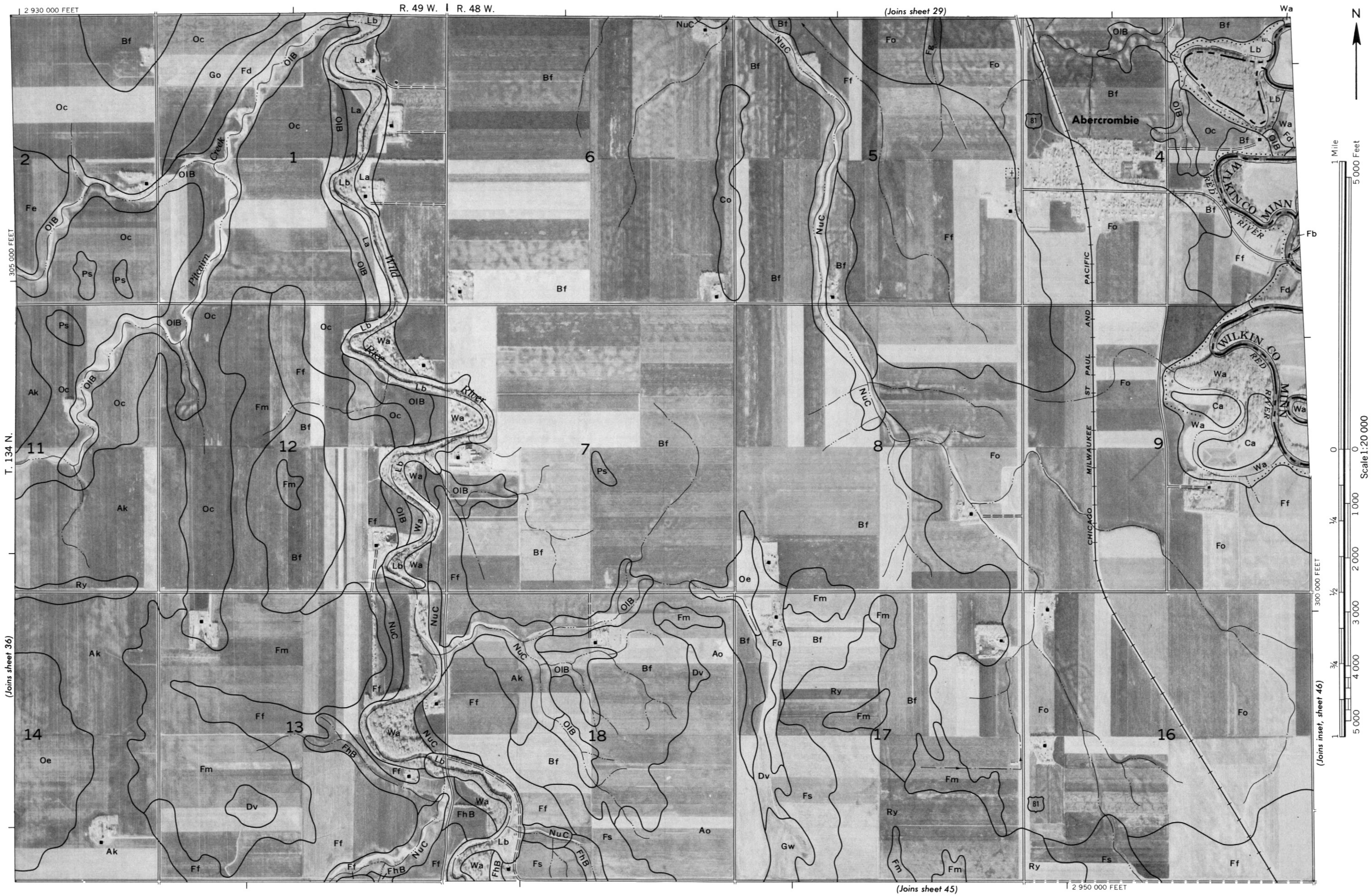
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 36

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 36

Land division corners are approximately positioned on this map.

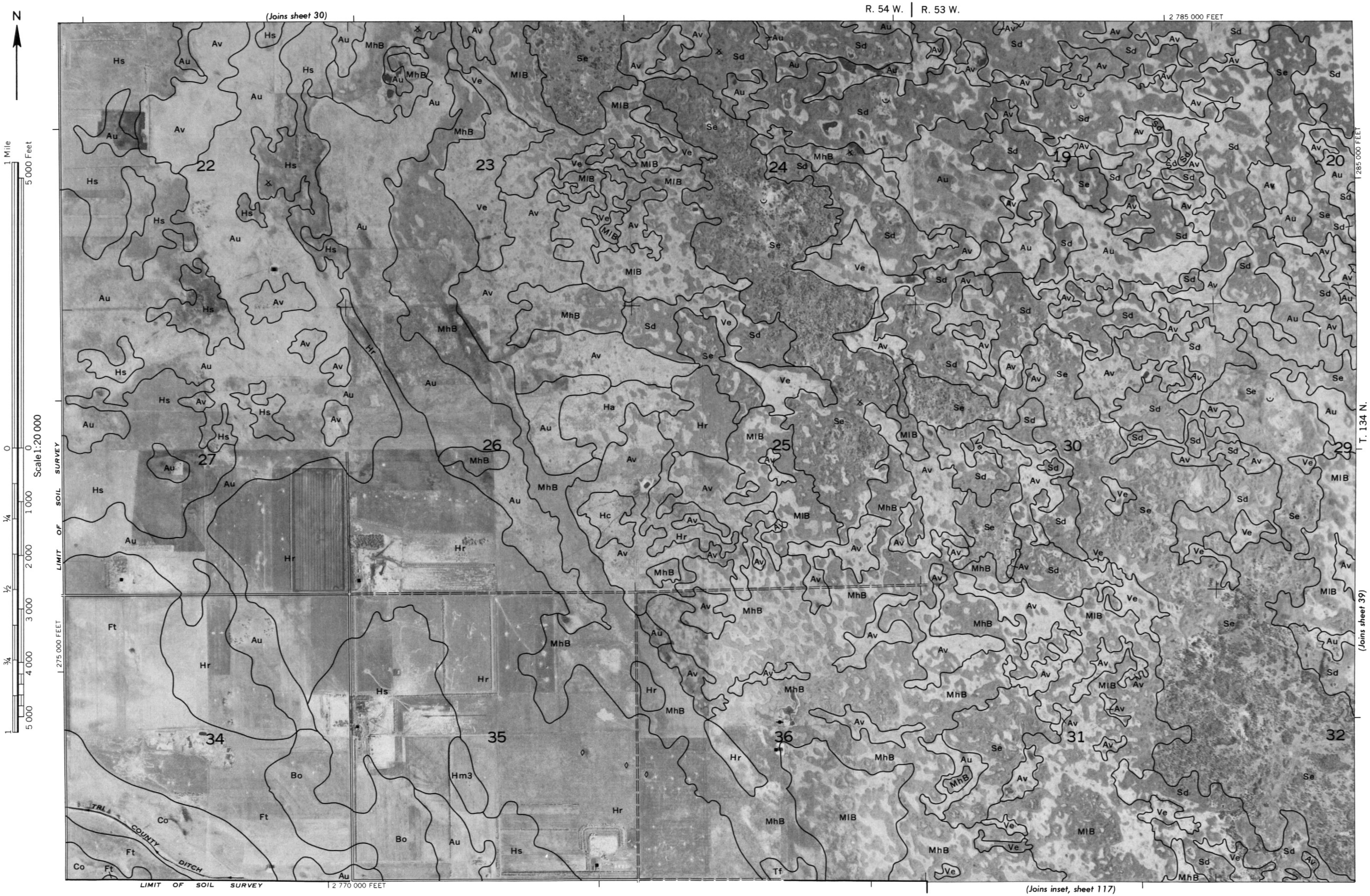
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 37

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 38



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 38

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

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Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 40

N

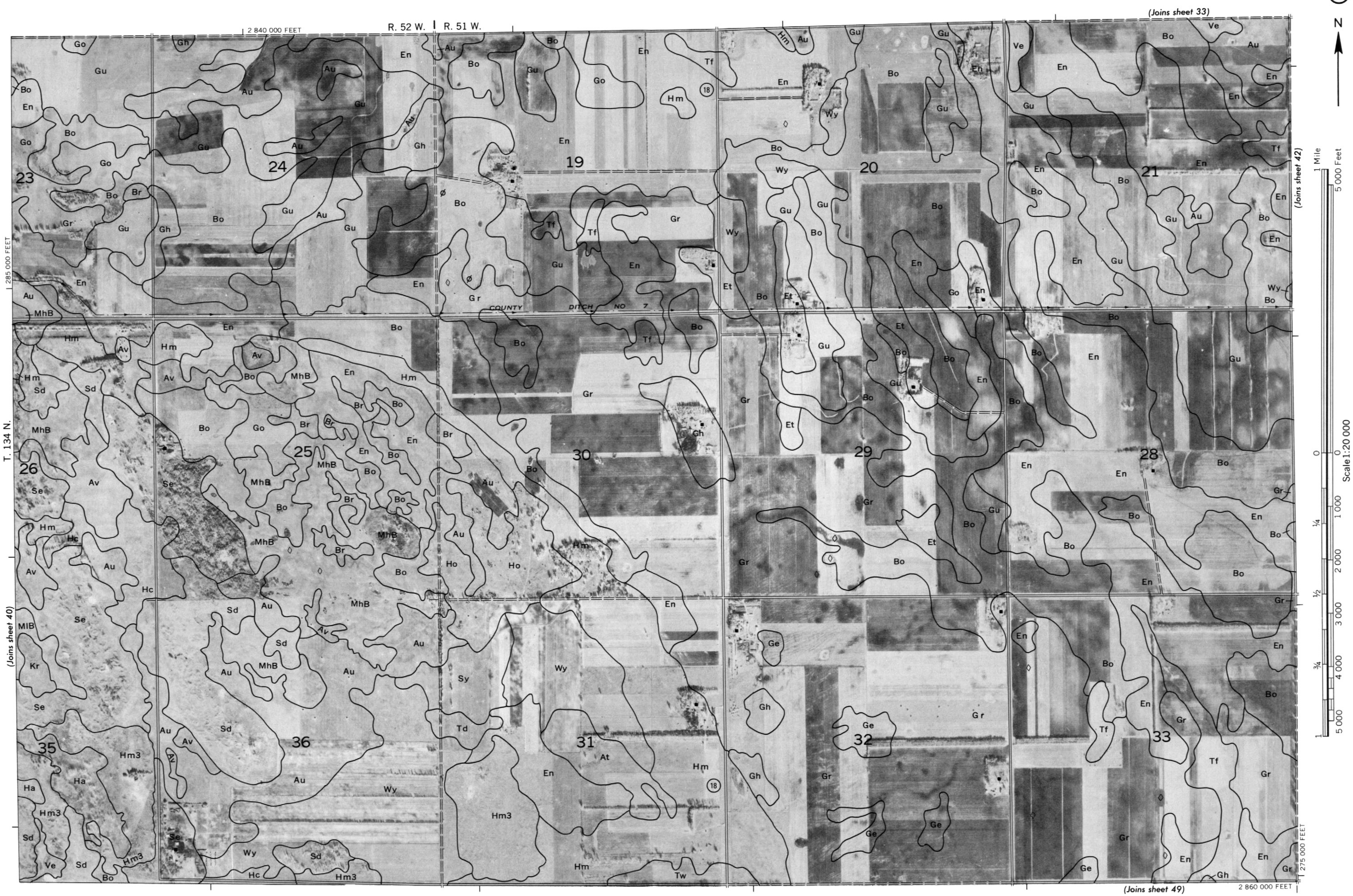
1 Mile
5 000 Feet
Scale 1:20 000
0 ¼ ½ ¾ 1
0 1 000 2 000 3 000 4 000 5 000

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 40

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

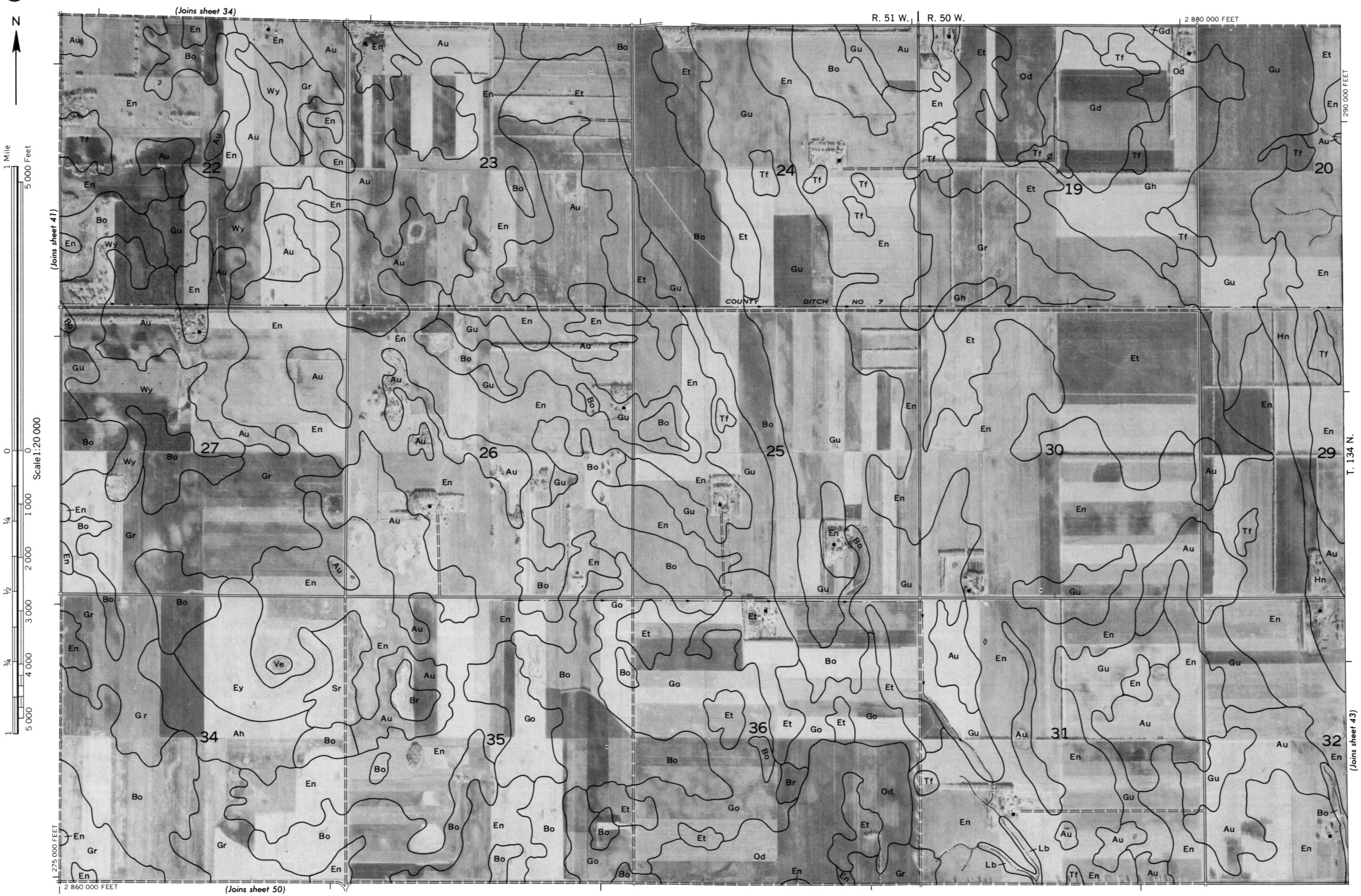
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 41

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 42

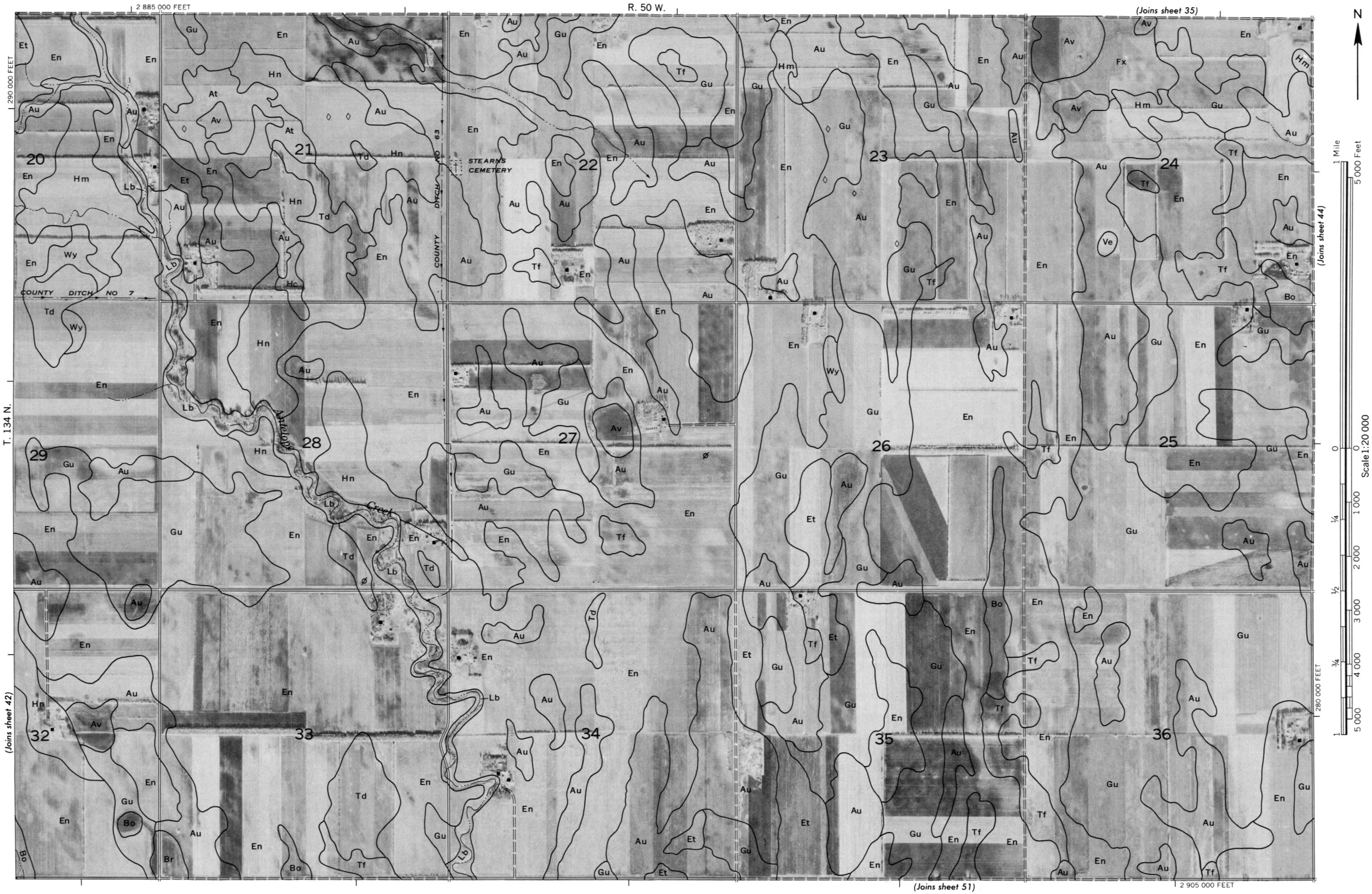


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 42

Land division corners are approximately positioned on this map.

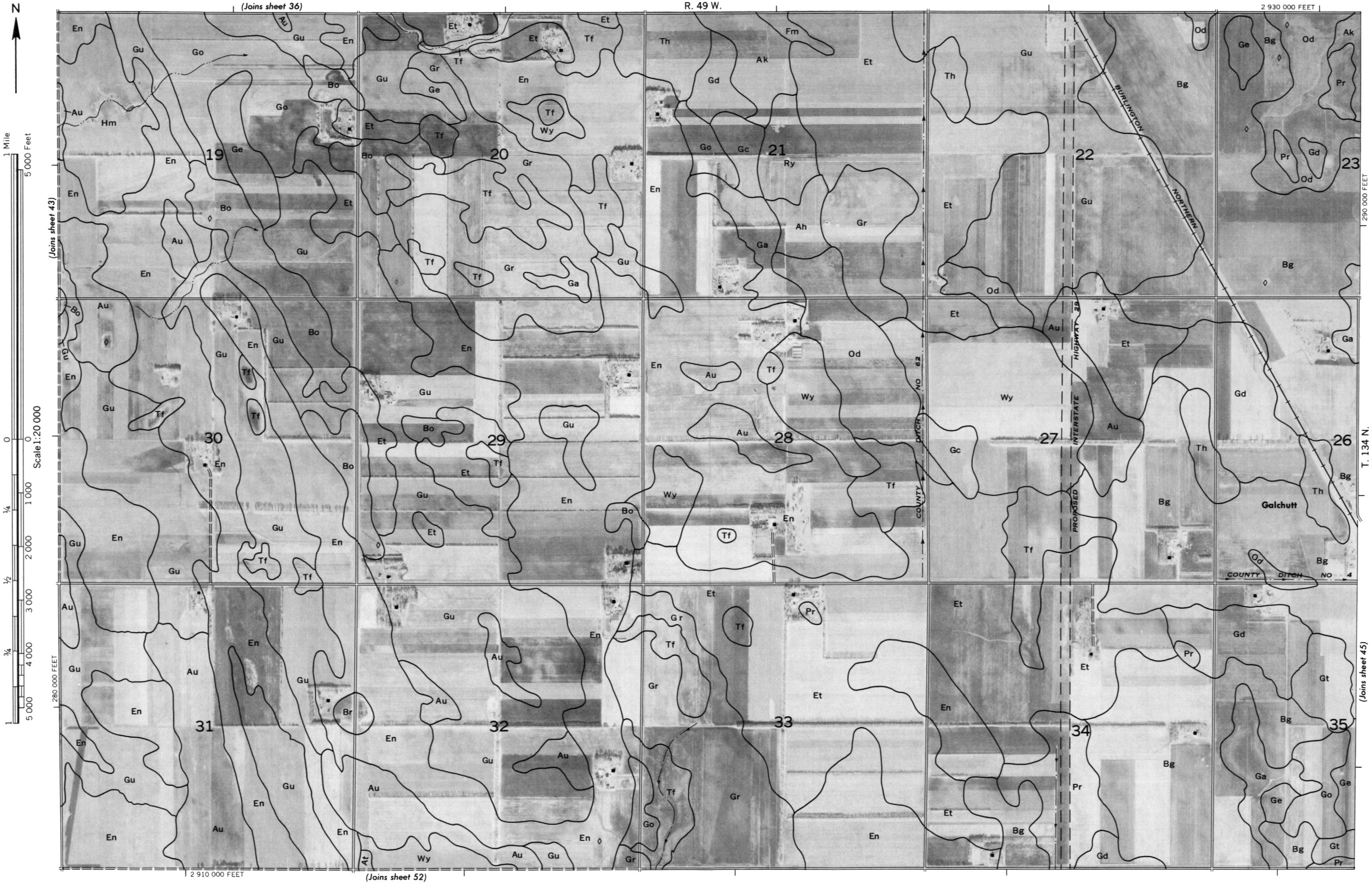
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 44



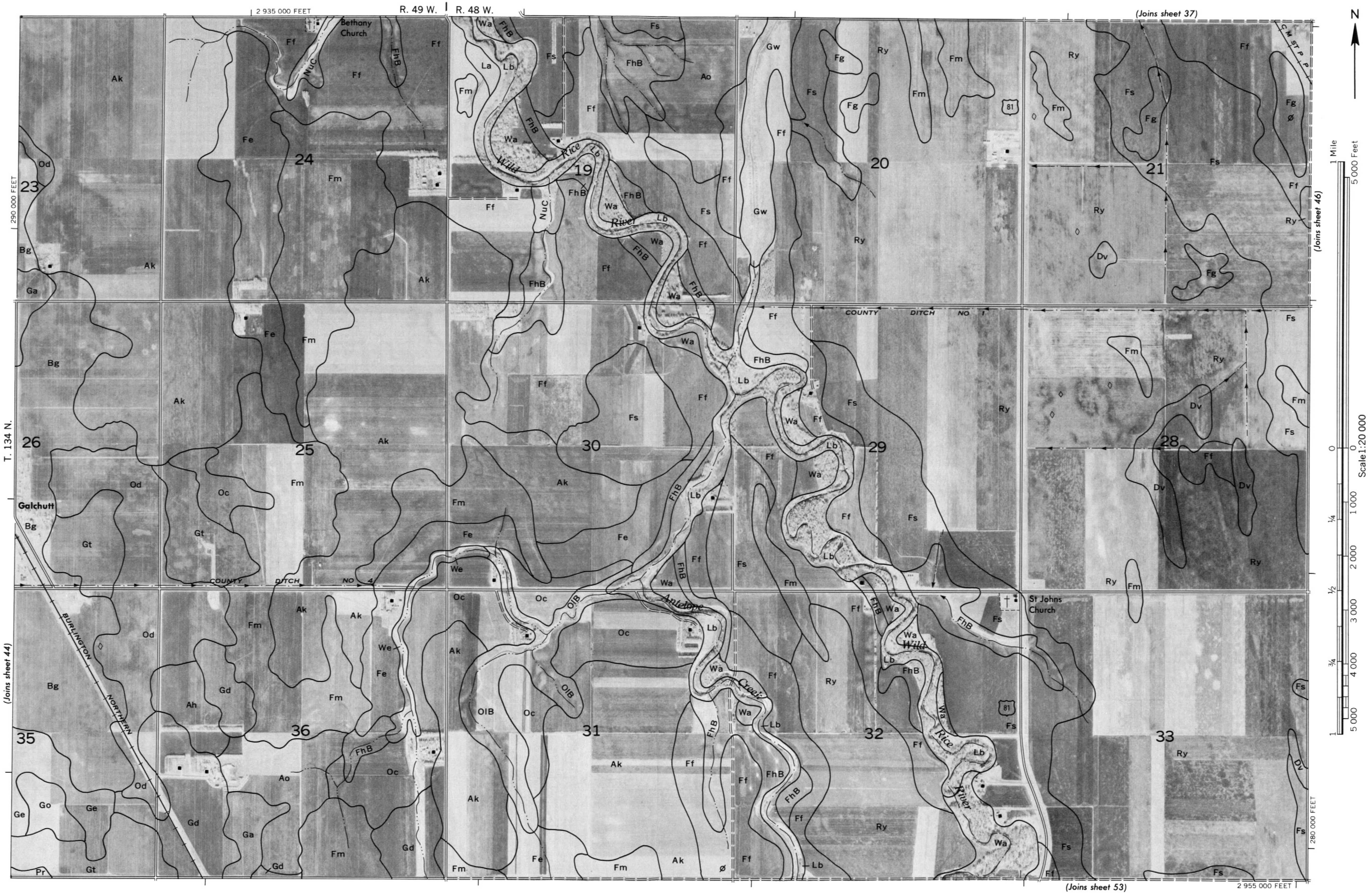
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 44

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

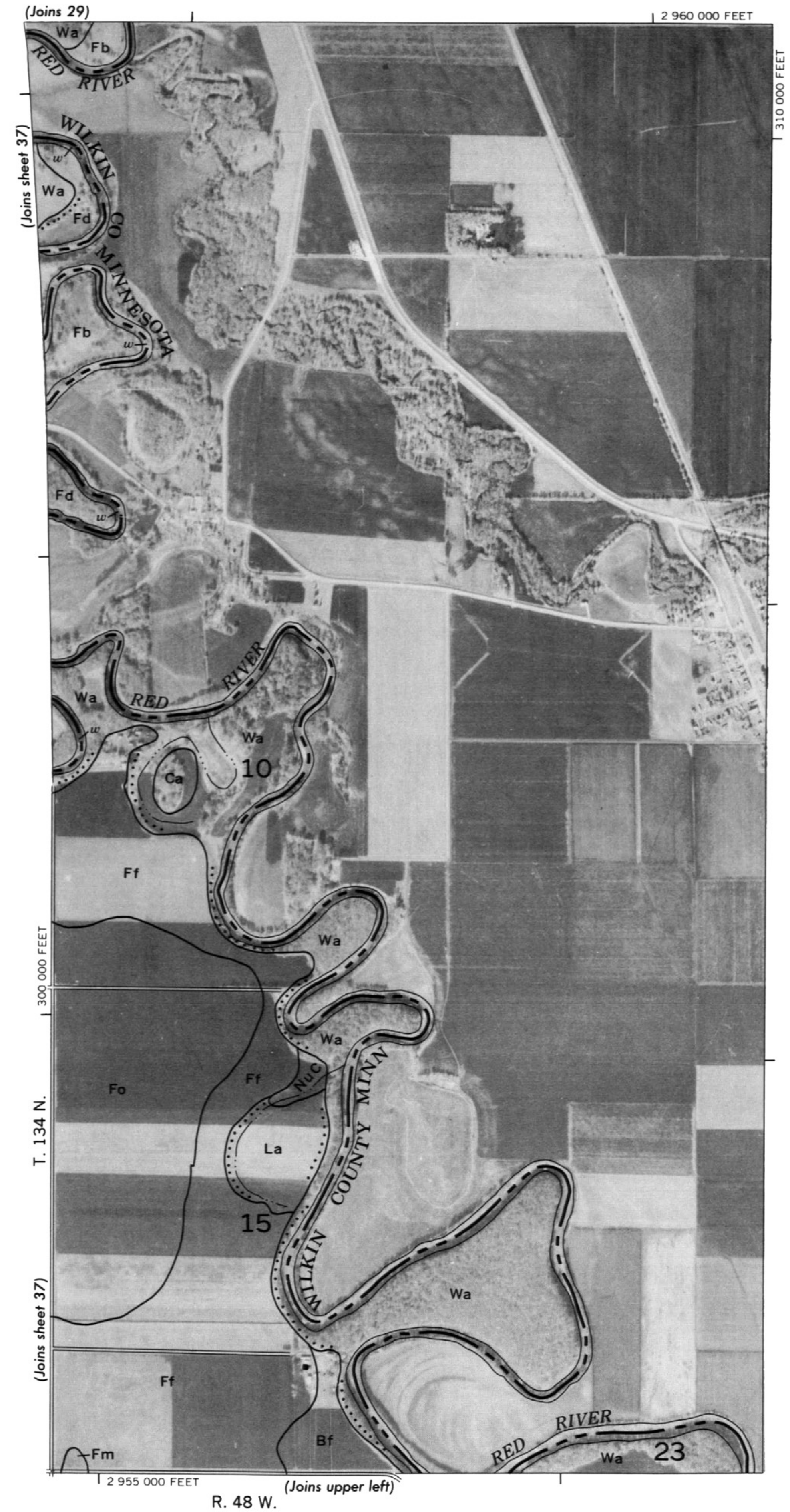
45



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 45

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 46

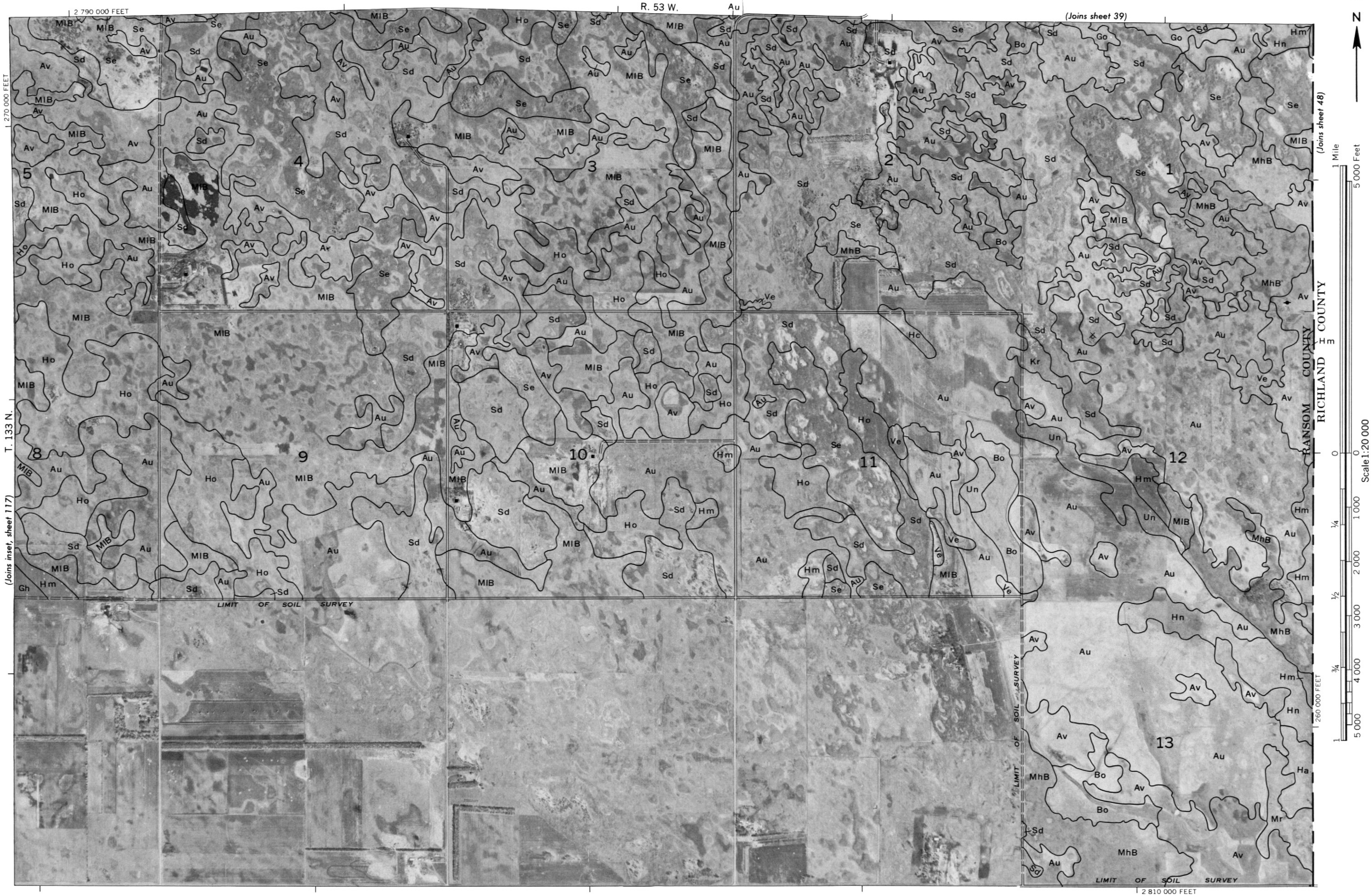


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 46

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

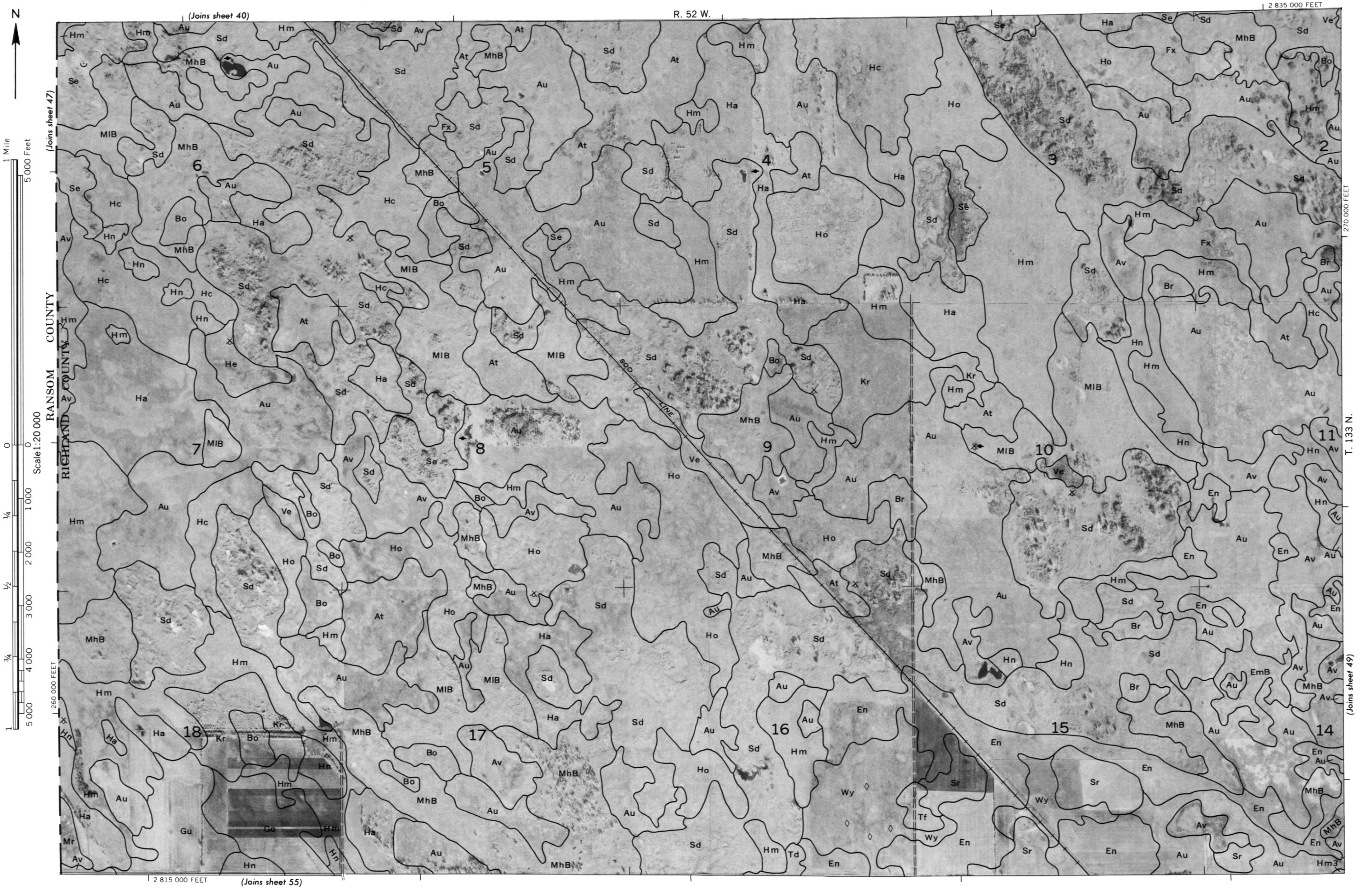
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 47

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 48

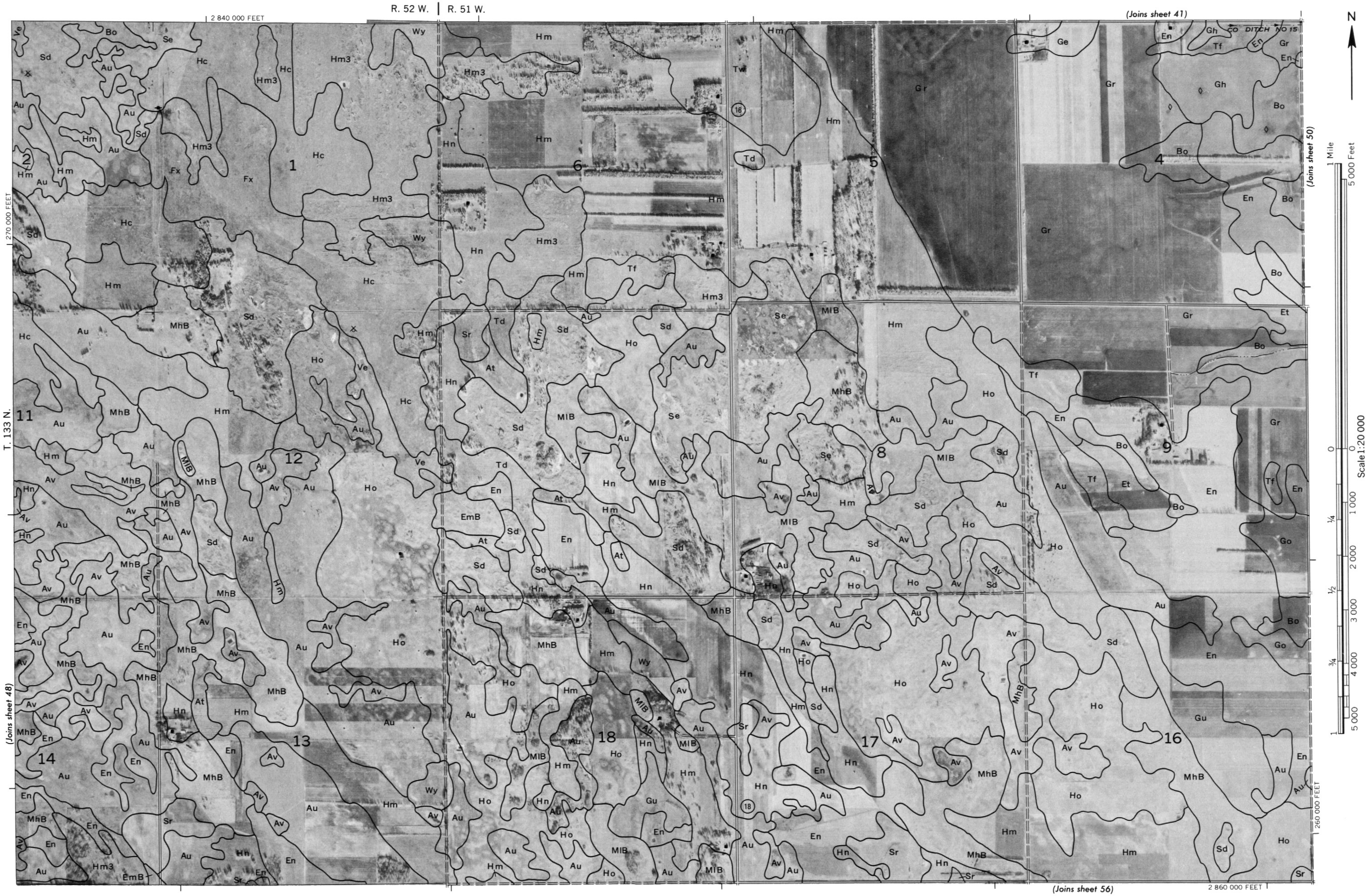


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 48

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

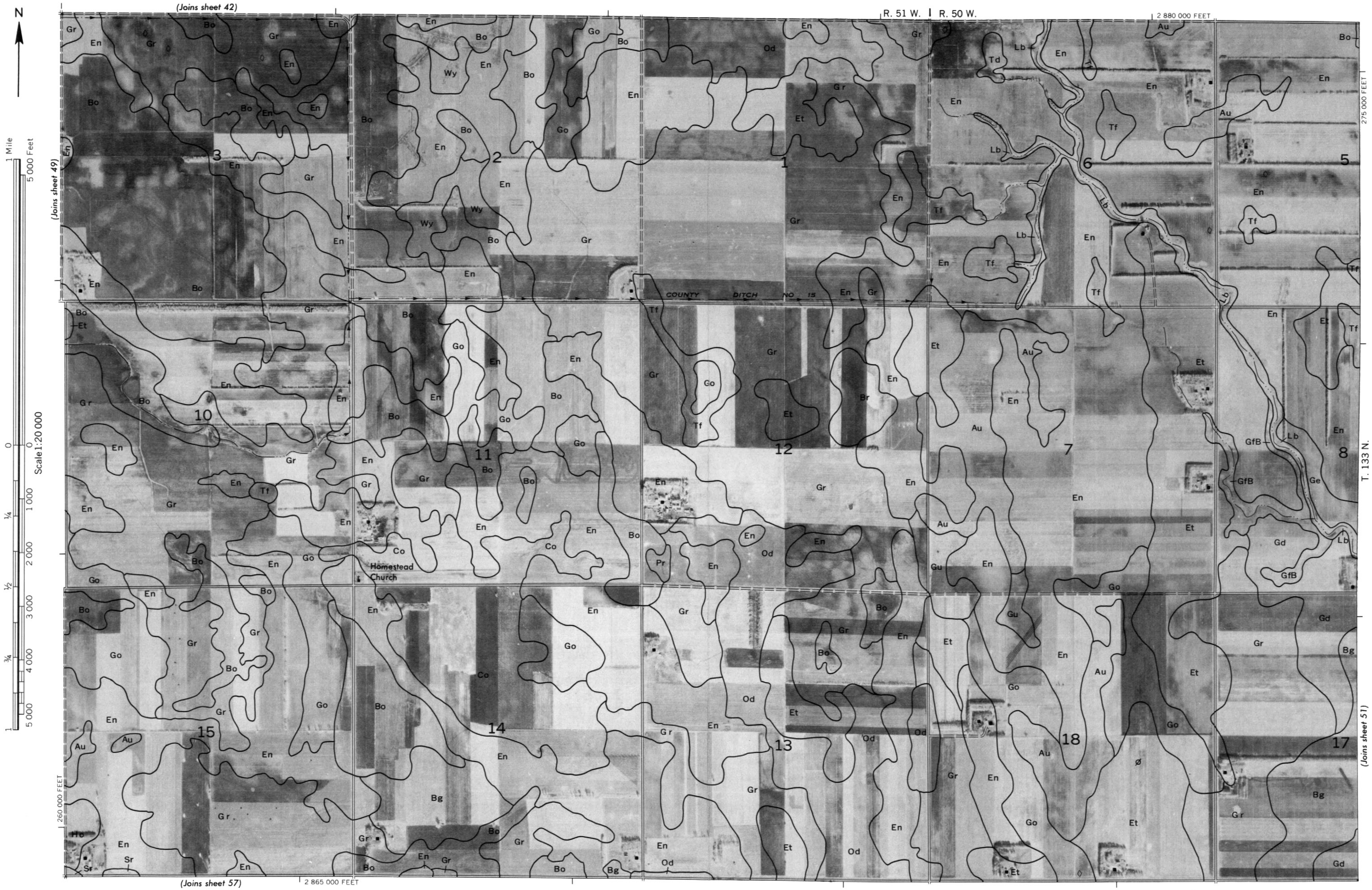
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 49

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 50

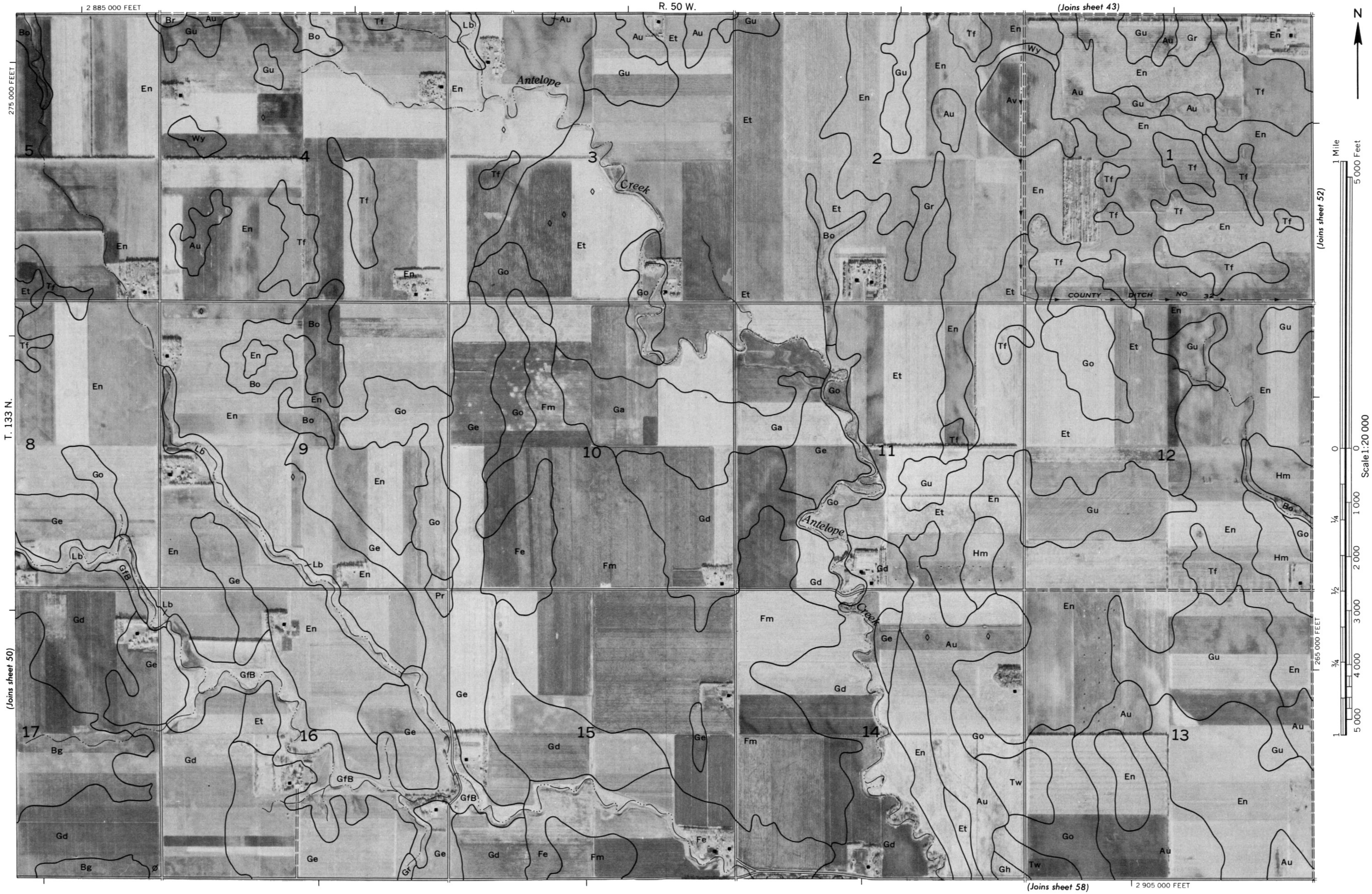


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 50

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

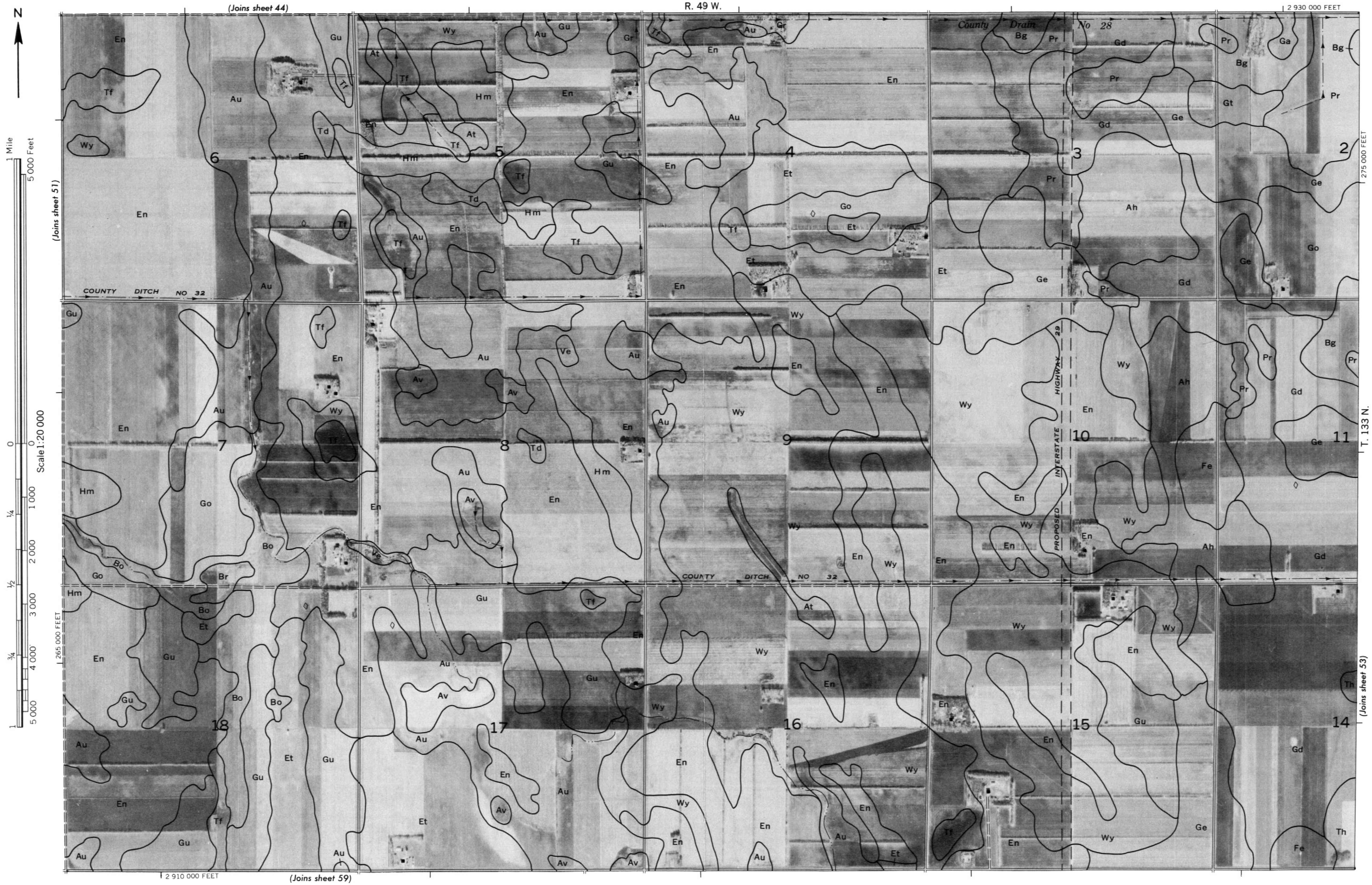


This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 51

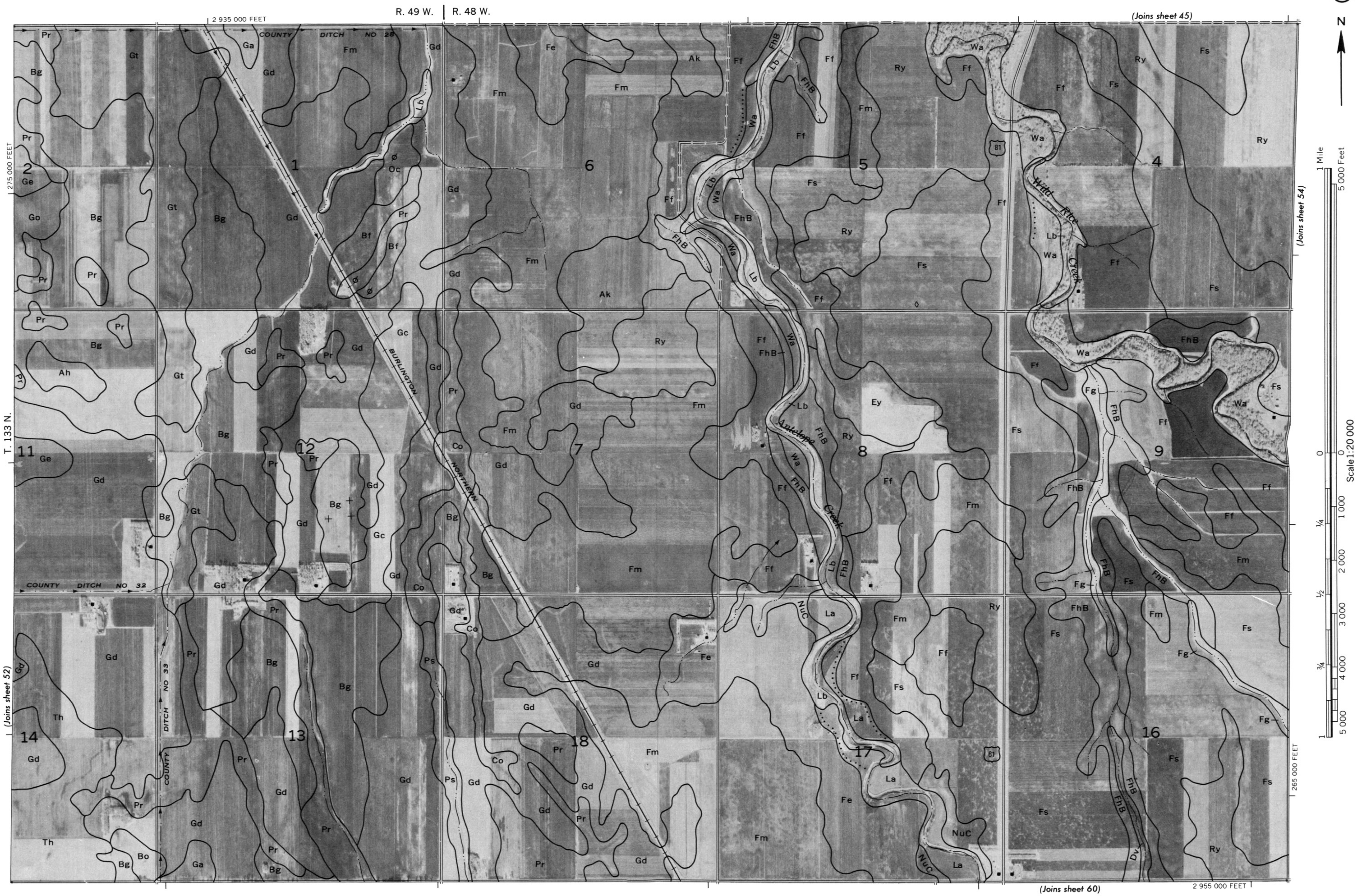


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 52

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

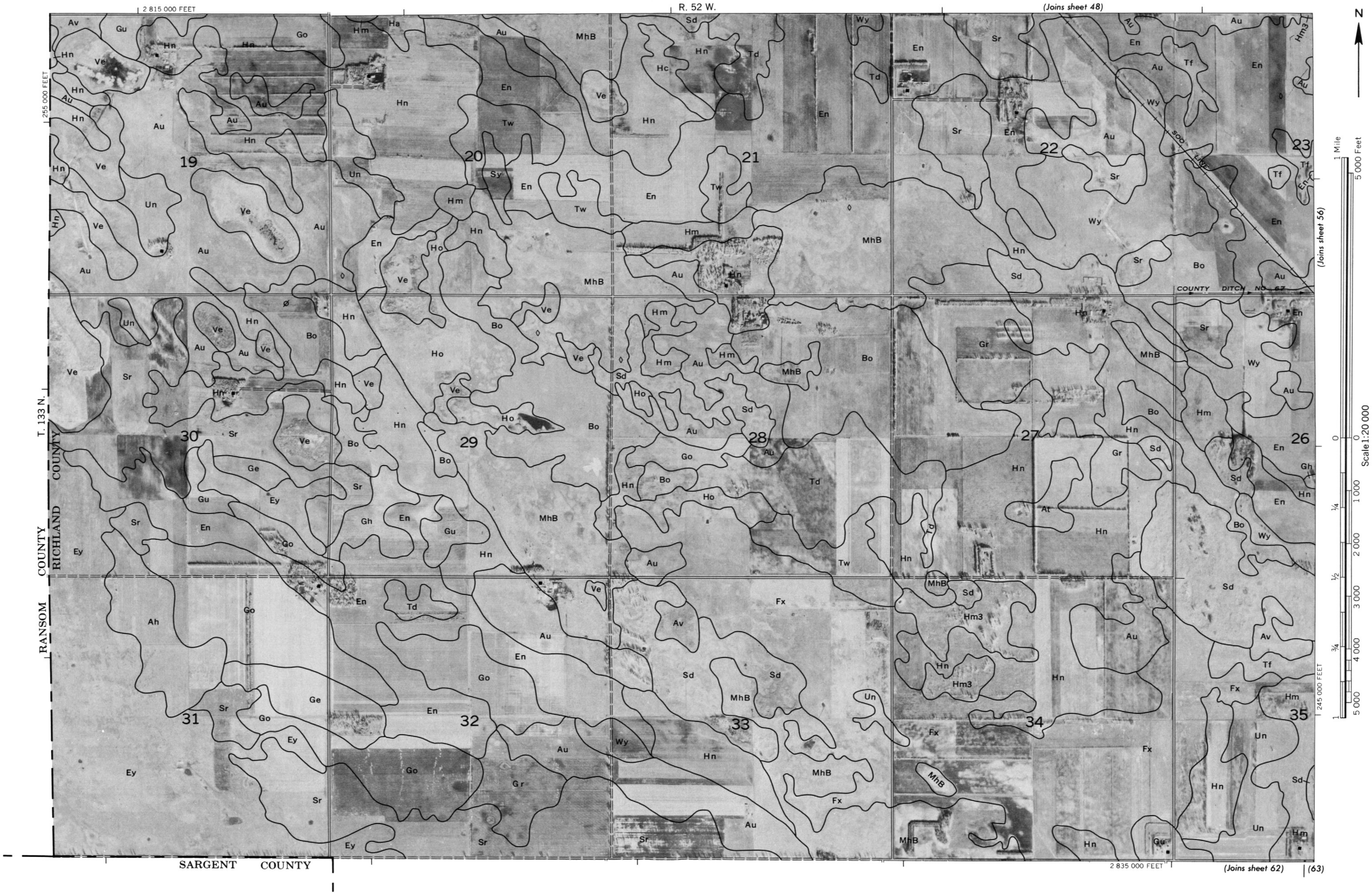
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 53

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 54

Land division corners are approximately positioned on this map.

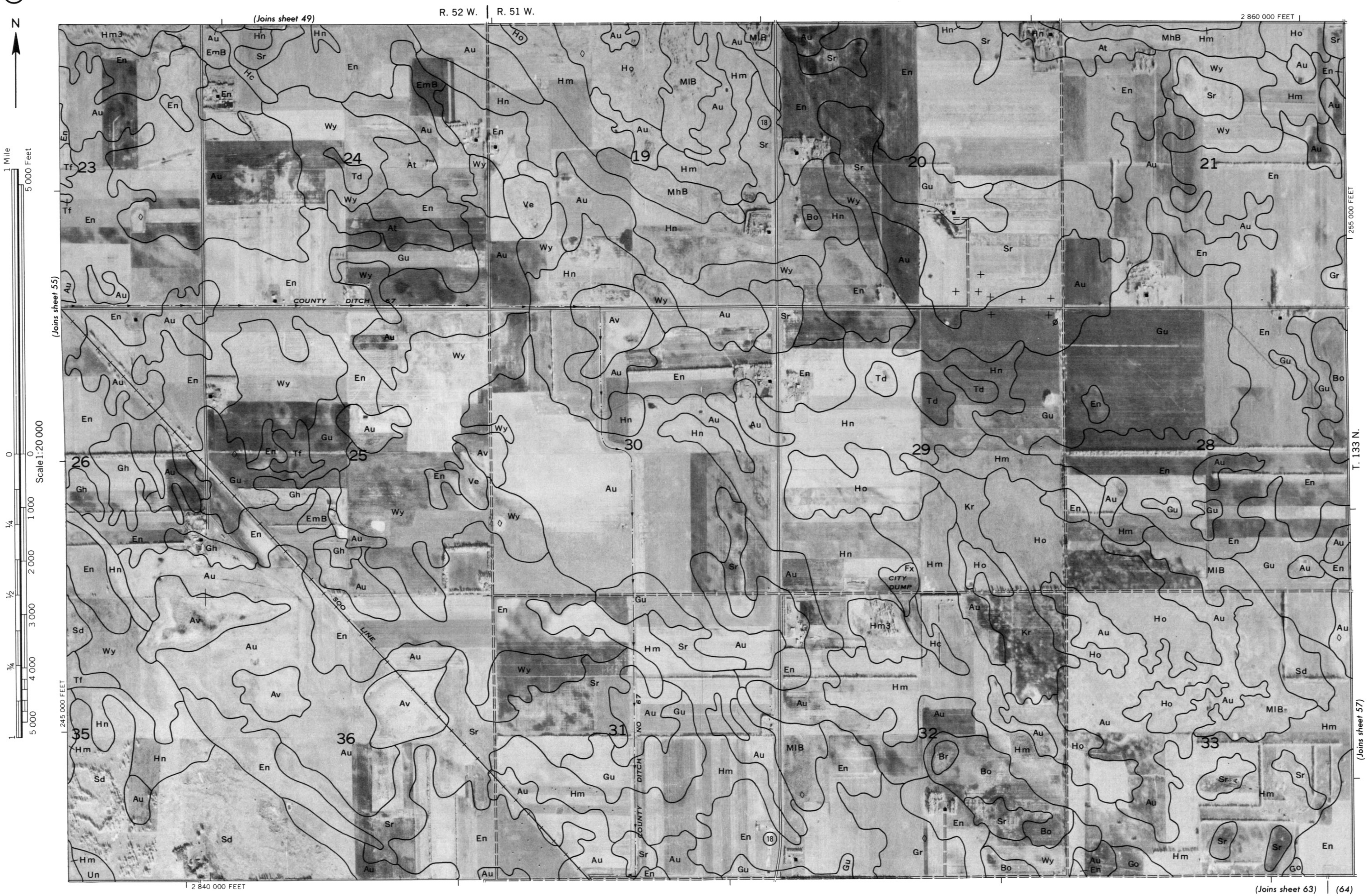
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station. Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone. Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 56

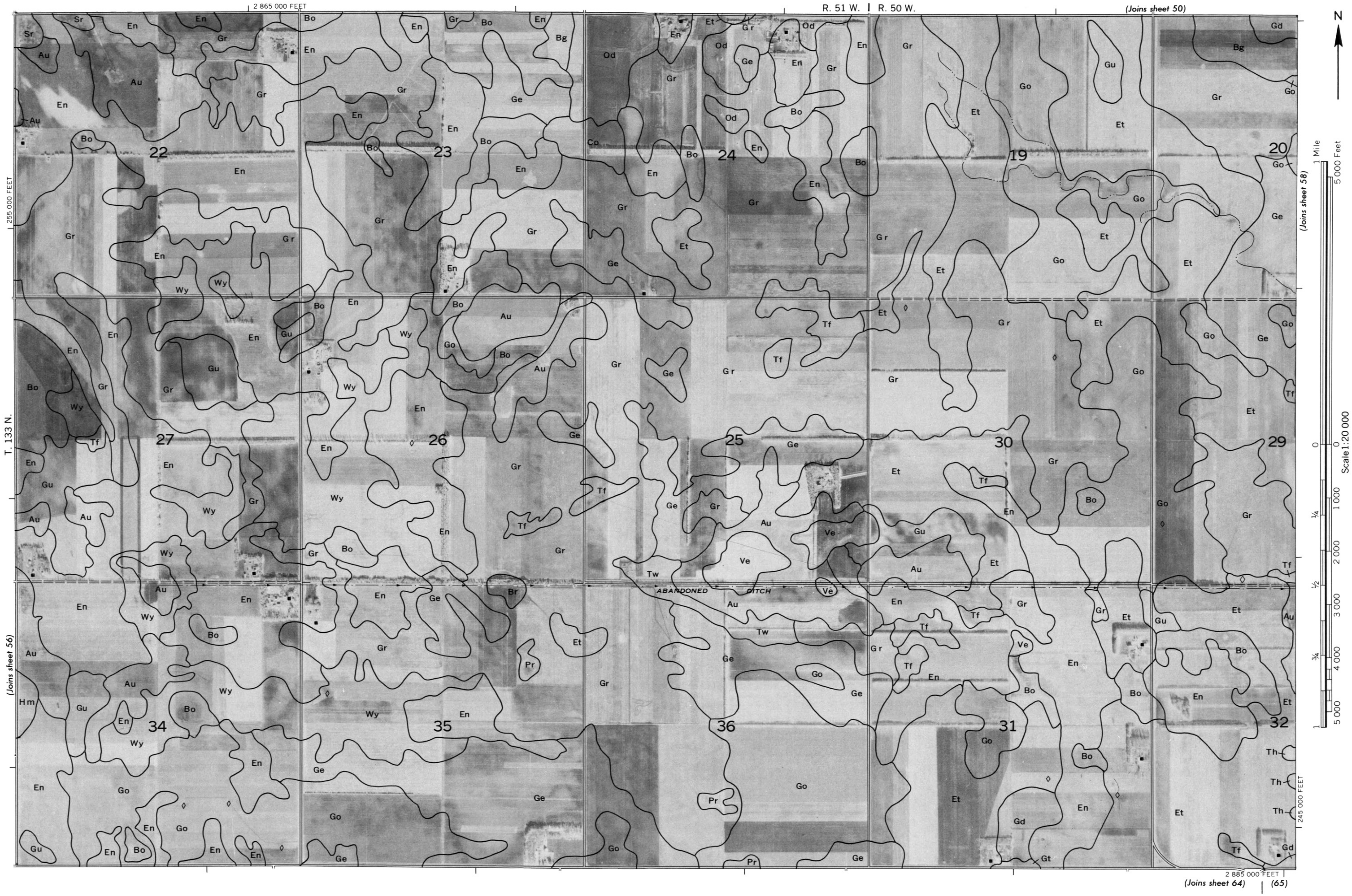


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 56

Land division corners are approximately positioned on this map.

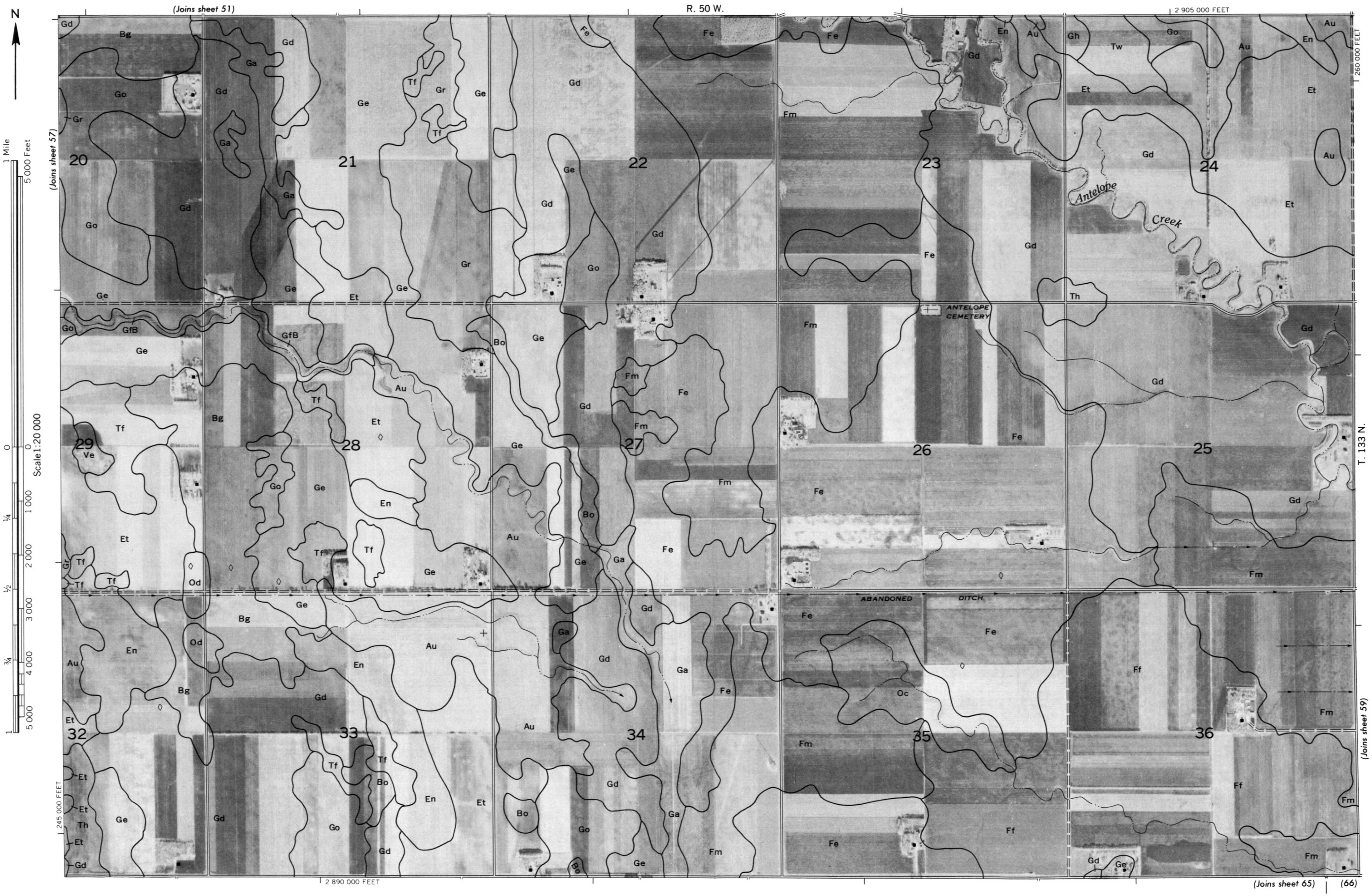
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 57

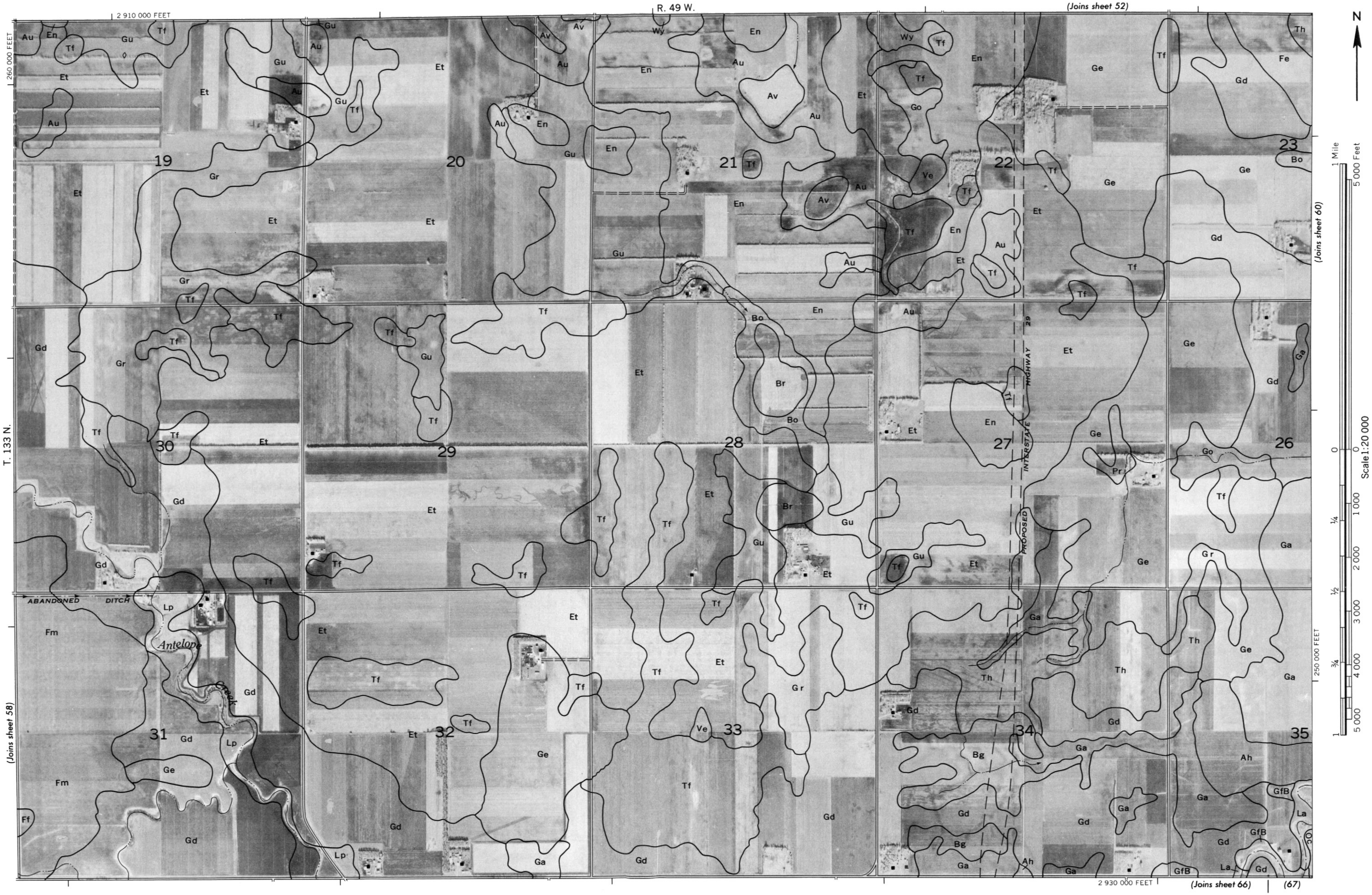


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 58

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

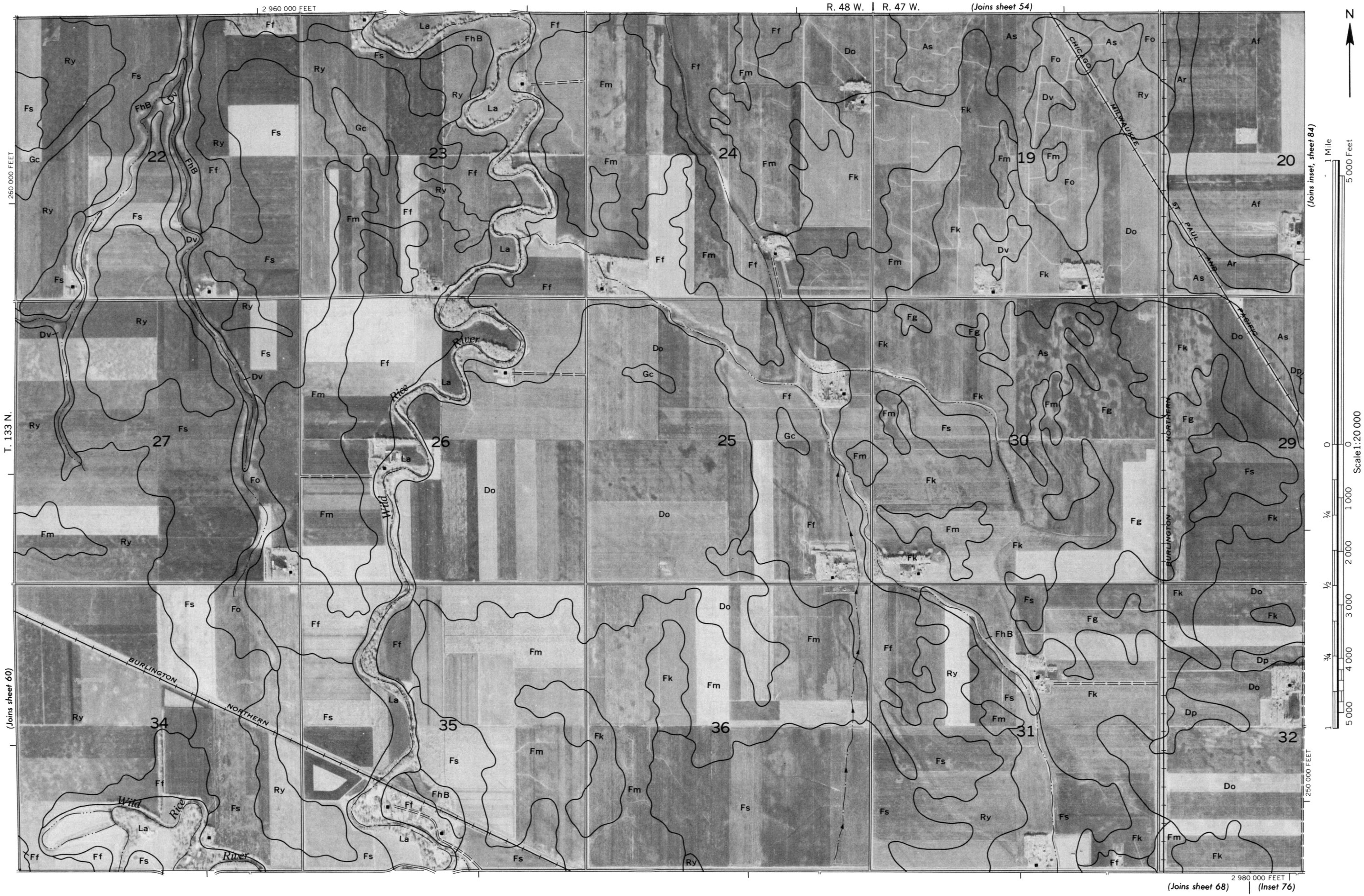
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 60

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 60

Land division corners are approximately positioned on this map.

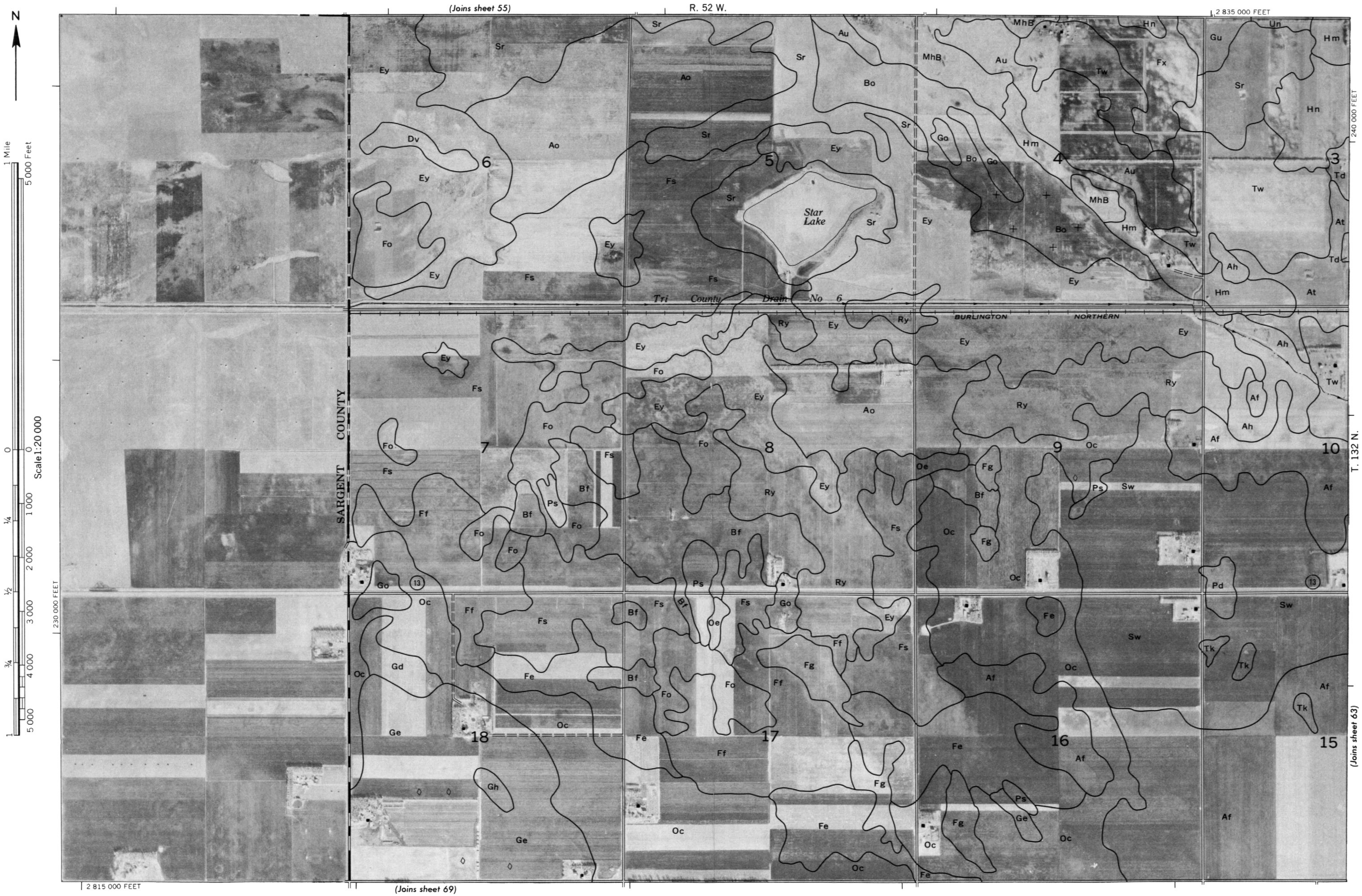
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 62

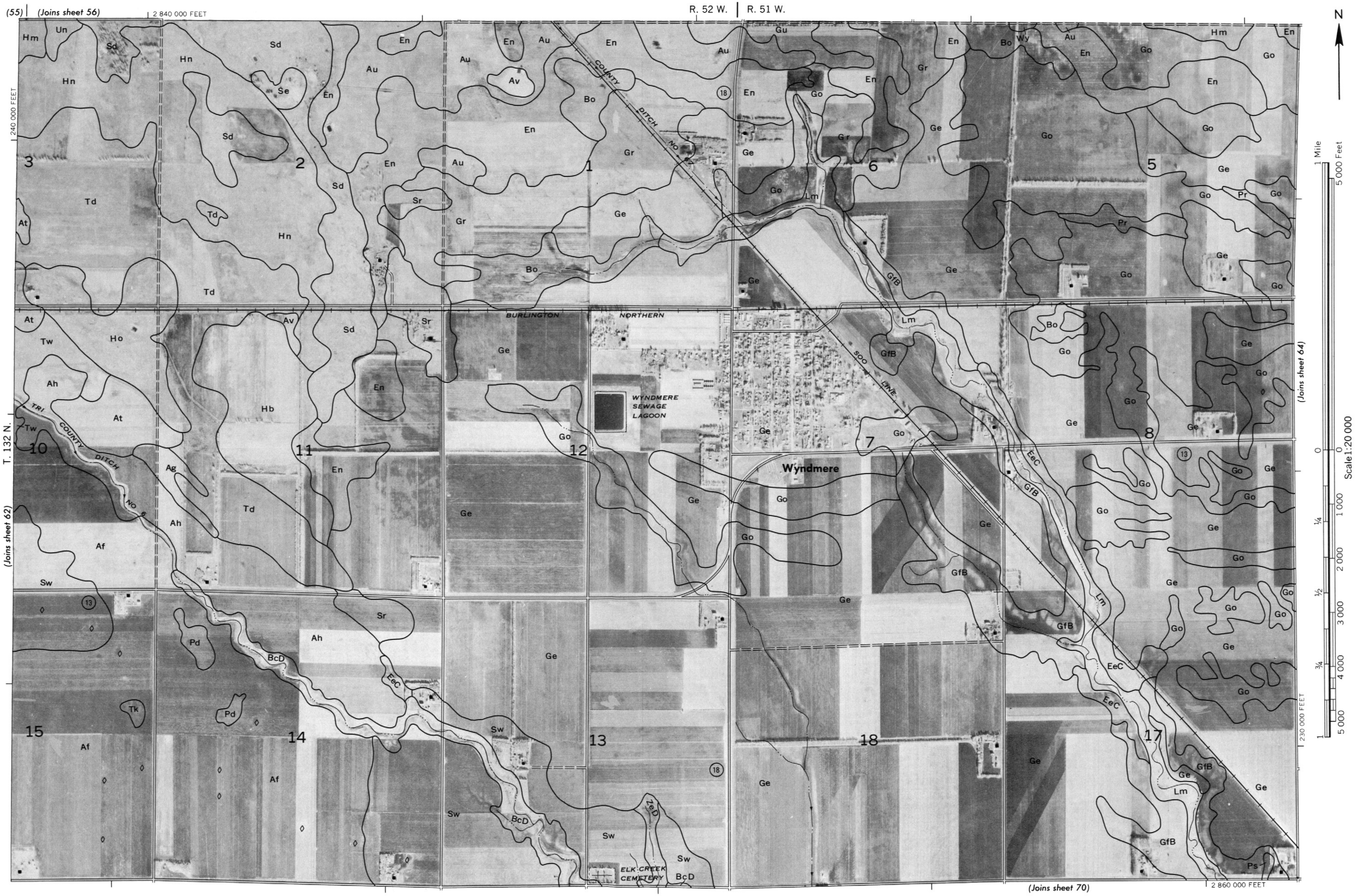


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 62

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

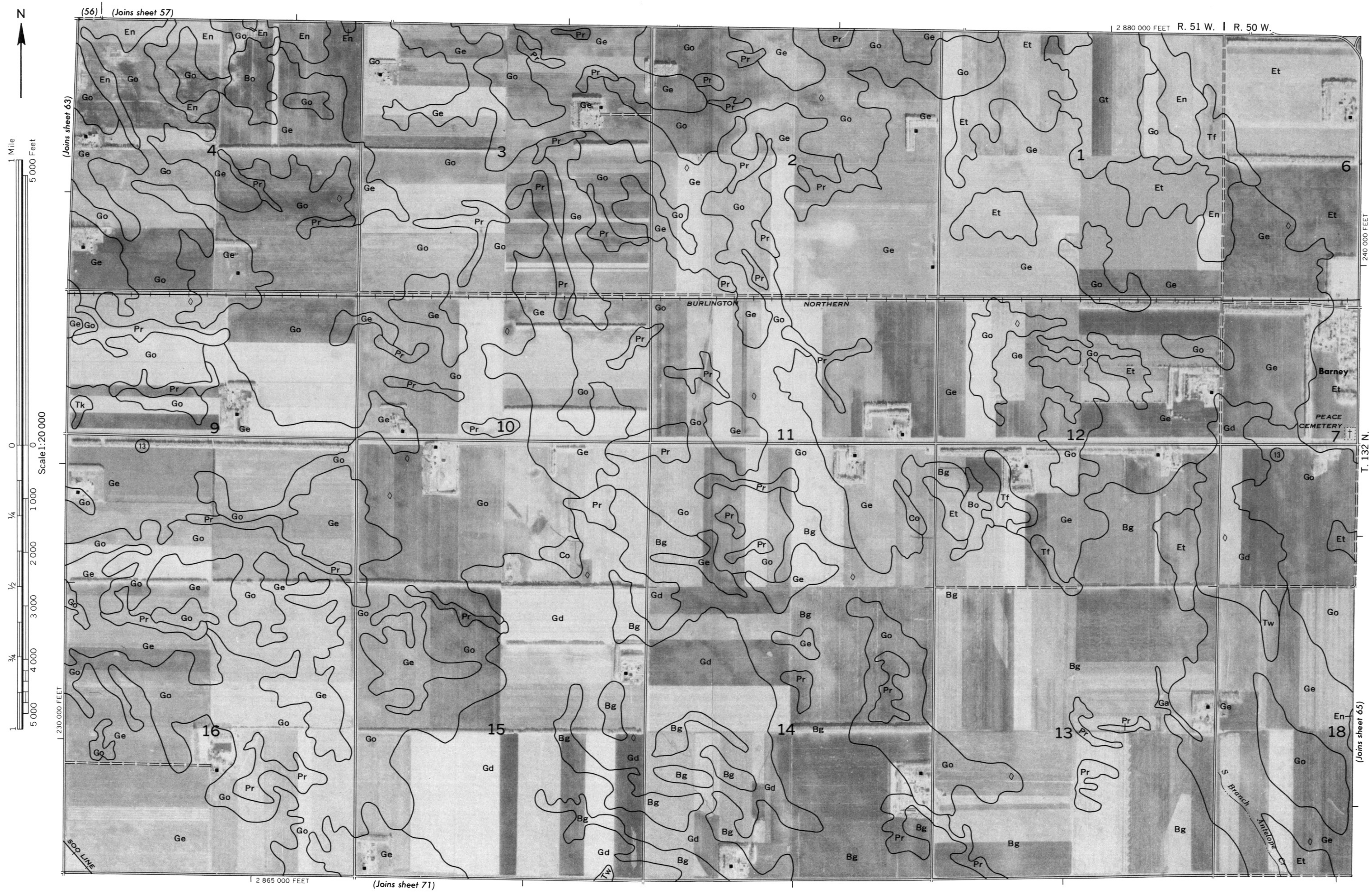


This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 64



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 64

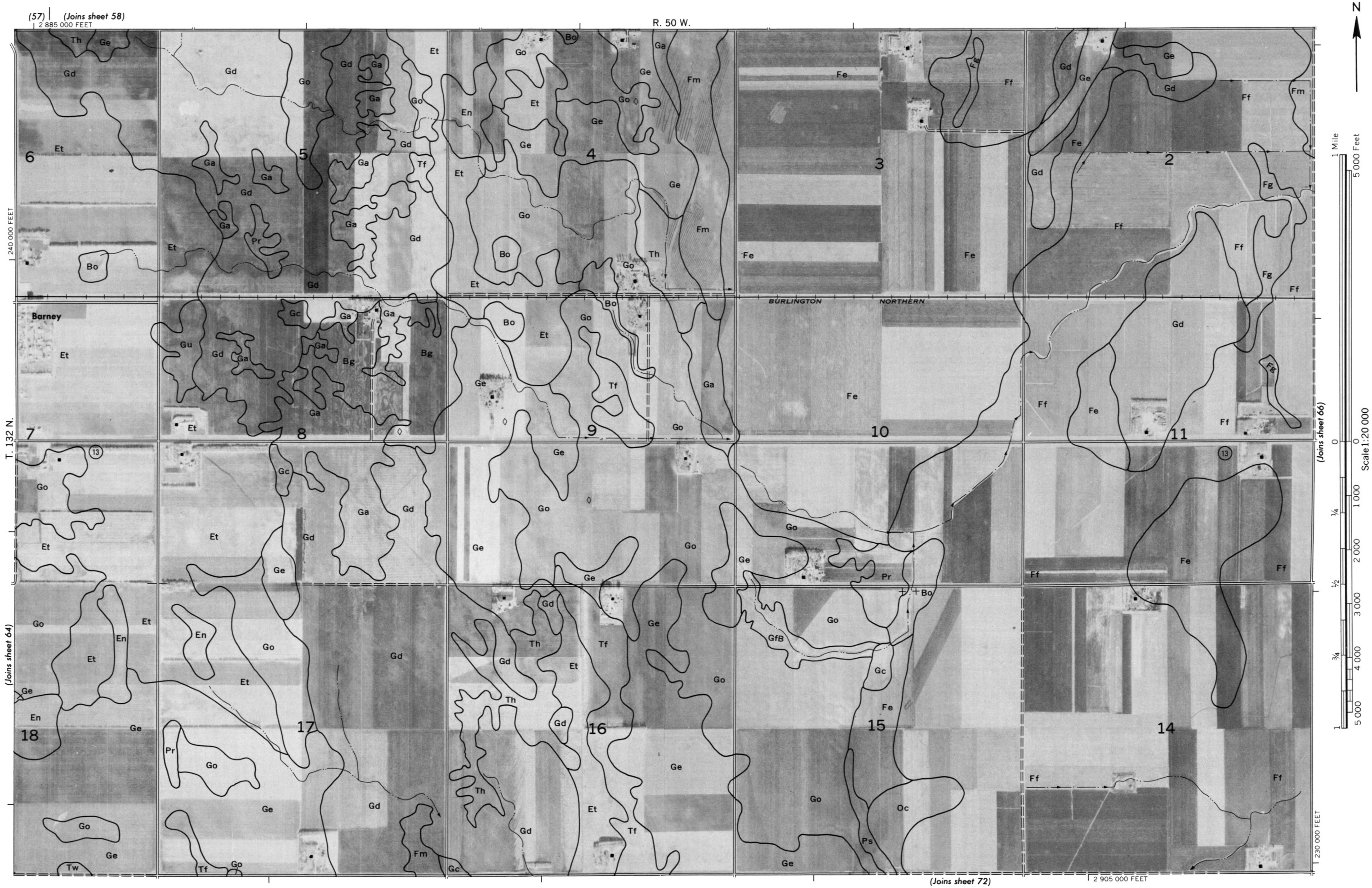
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

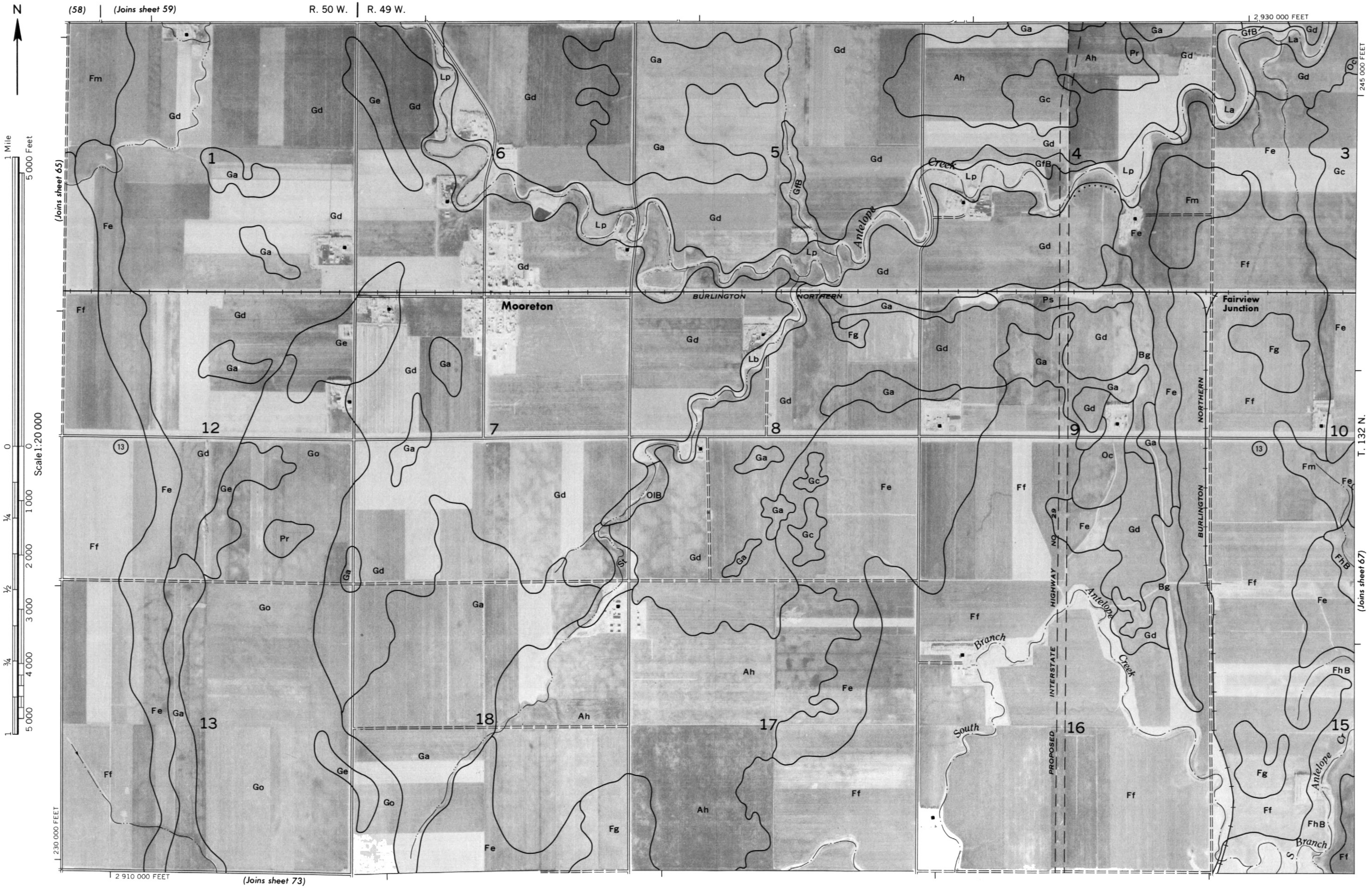
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 65



RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 66



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 66

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

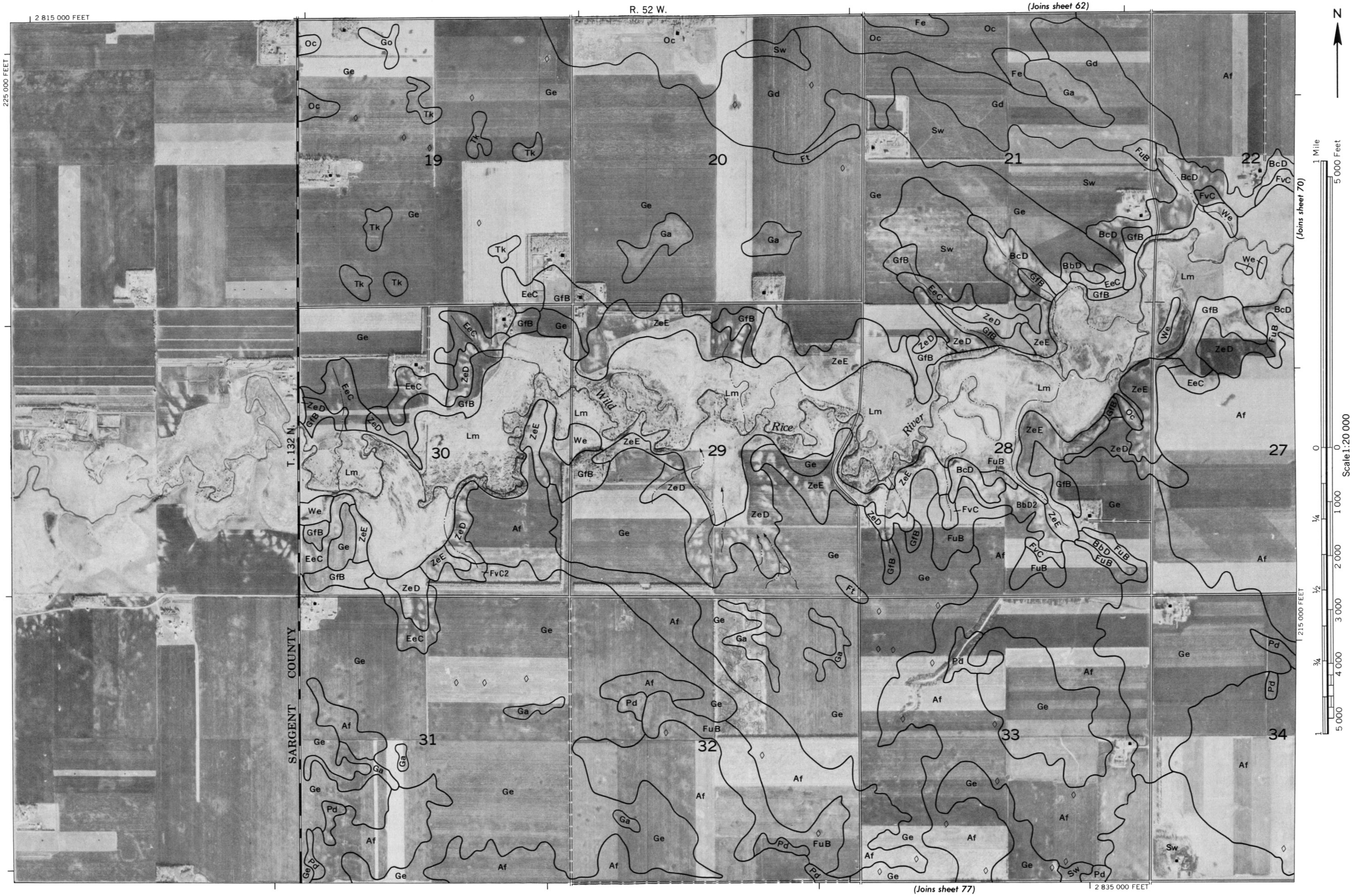
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 68

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO. N.D. NO. 68

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



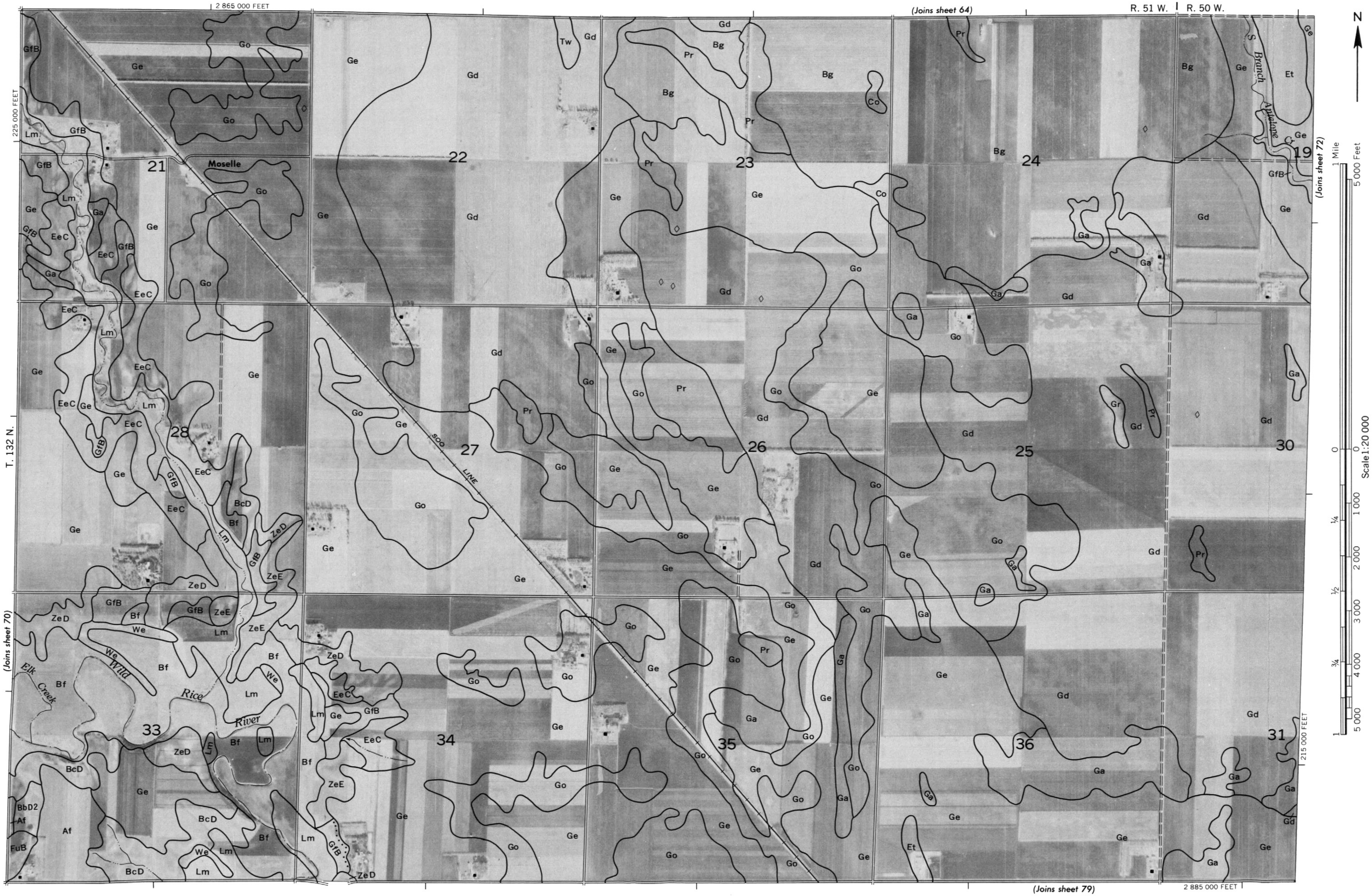
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 70

Land division corners are approximately positioned on this map.

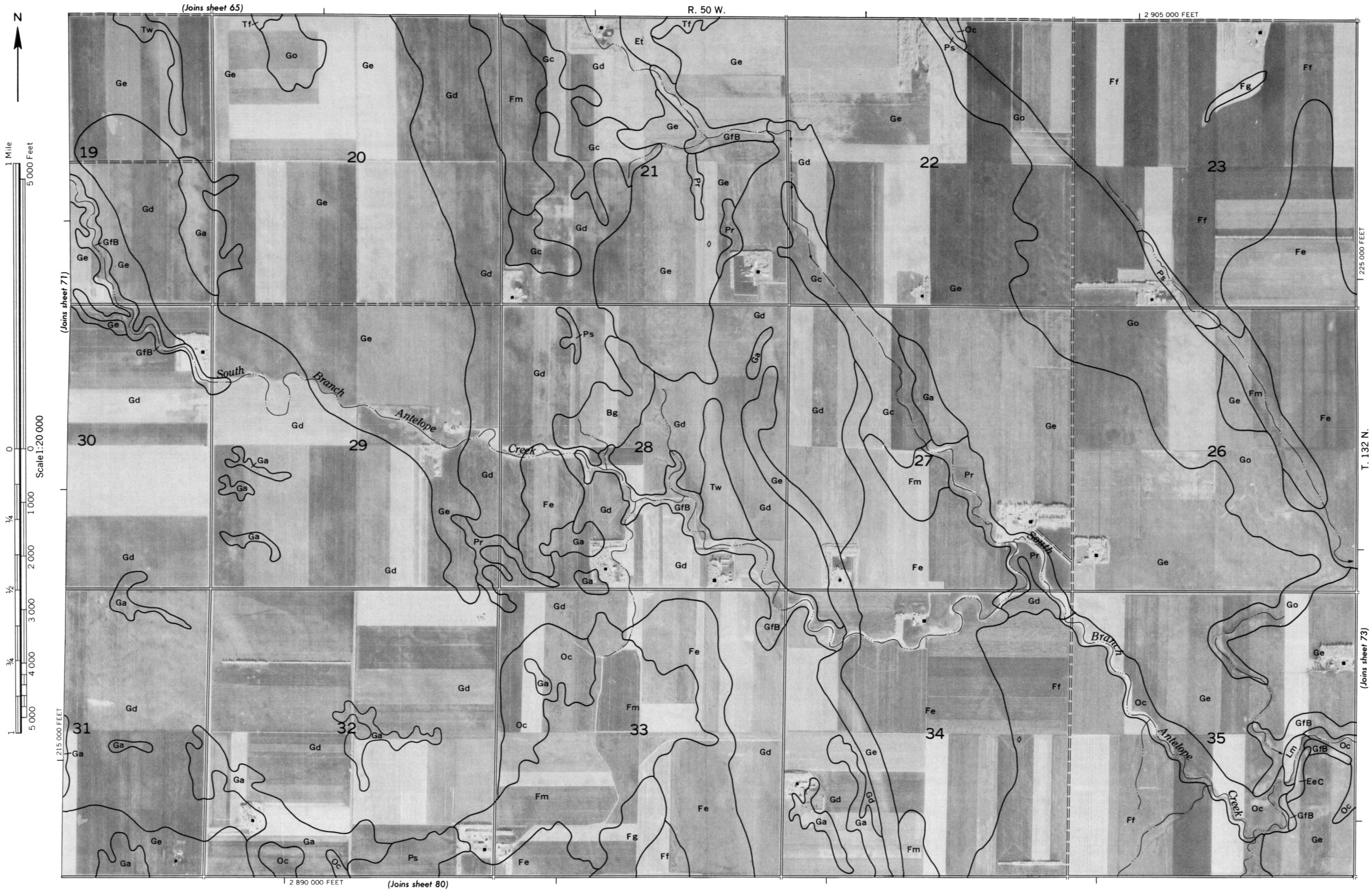
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 71



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO. N.D. NO. 72

Land division corners are approximately positioned on this map.

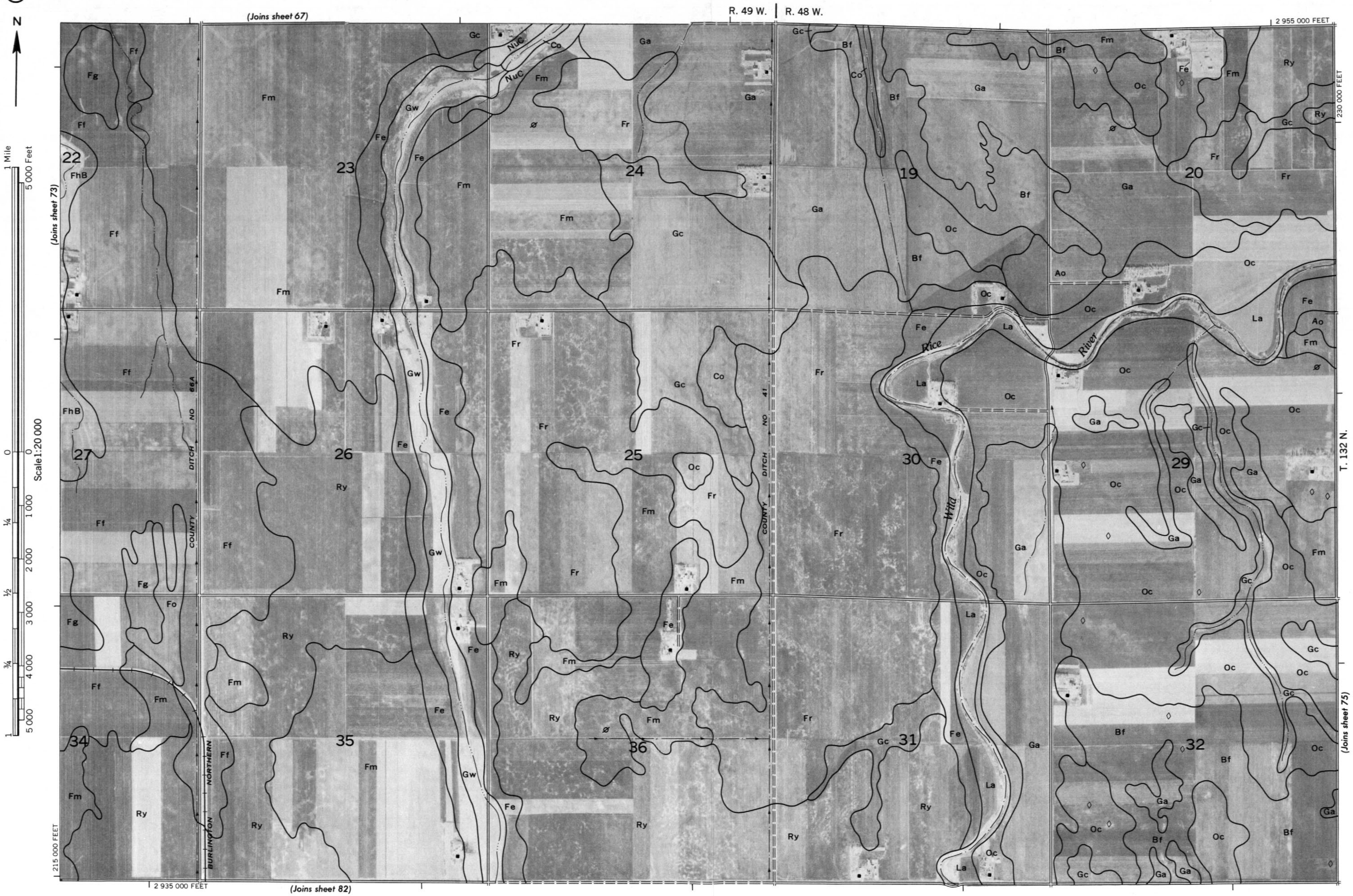
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 73

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 74

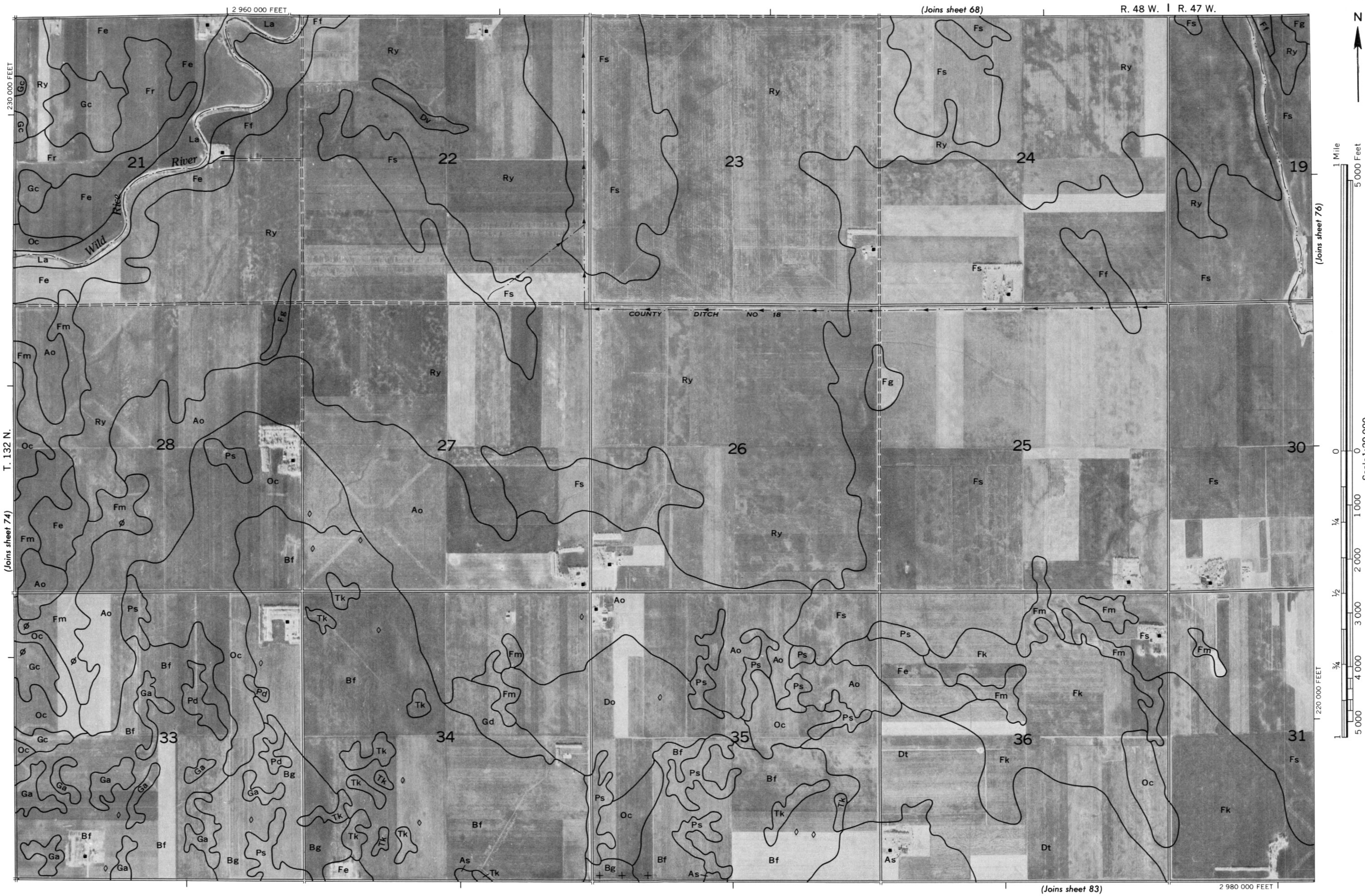


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 74

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 75

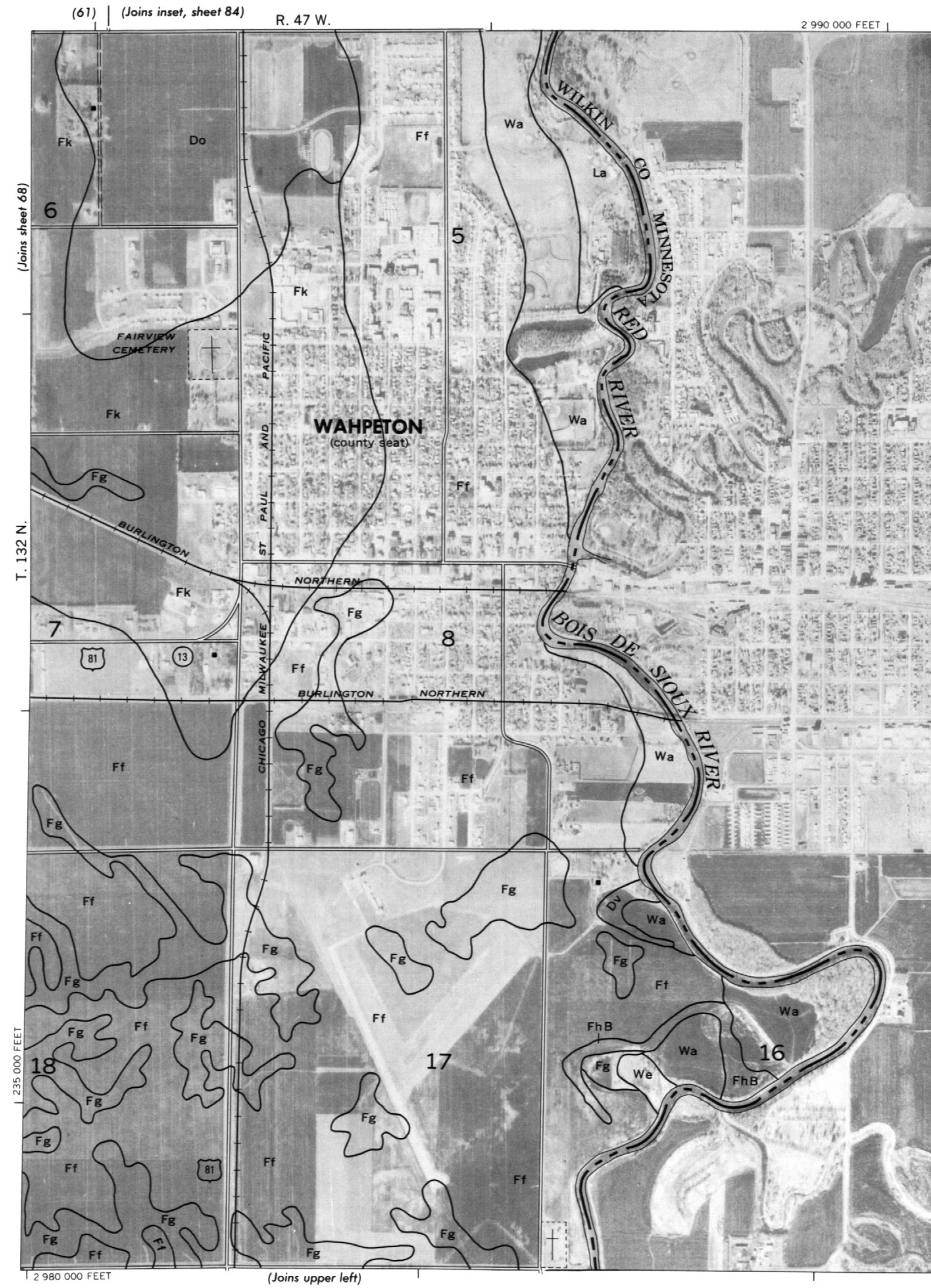
N

1 Mile 5 000 Feet

Scale 1:20 000

0 ¼ ½ ¾ 1

0 1 000 2 000 3 000 4 000 5 000



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 76

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 77

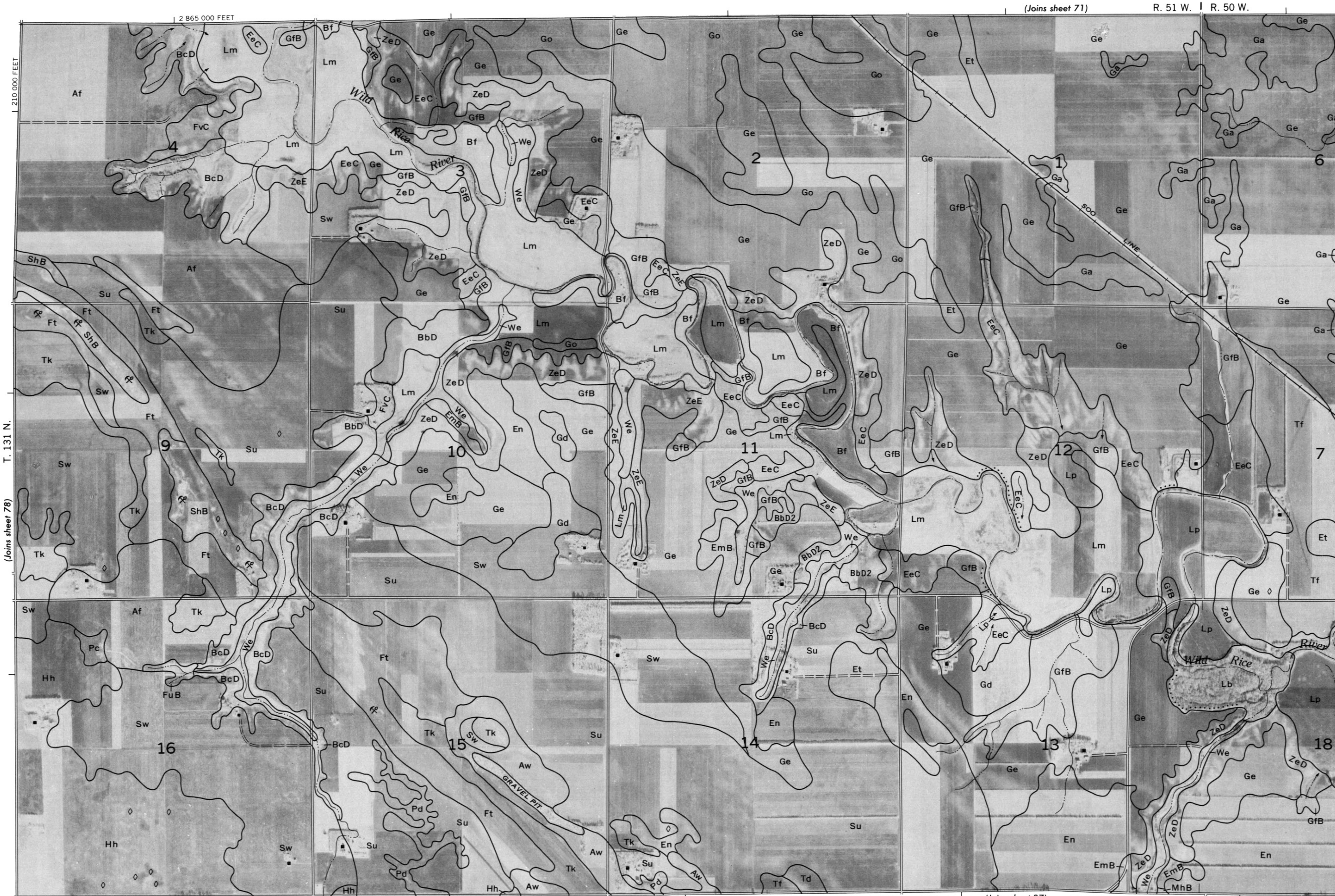
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 78

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 78

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



N

Scale 1:20 000

1 Mile: 0, 1/4, 1/2, 3/4, 1

5 000 Feet: 0, 1 000, 2 000, 3 000, 4 000, 5 000

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO. N.D. NO. 79

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 80

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

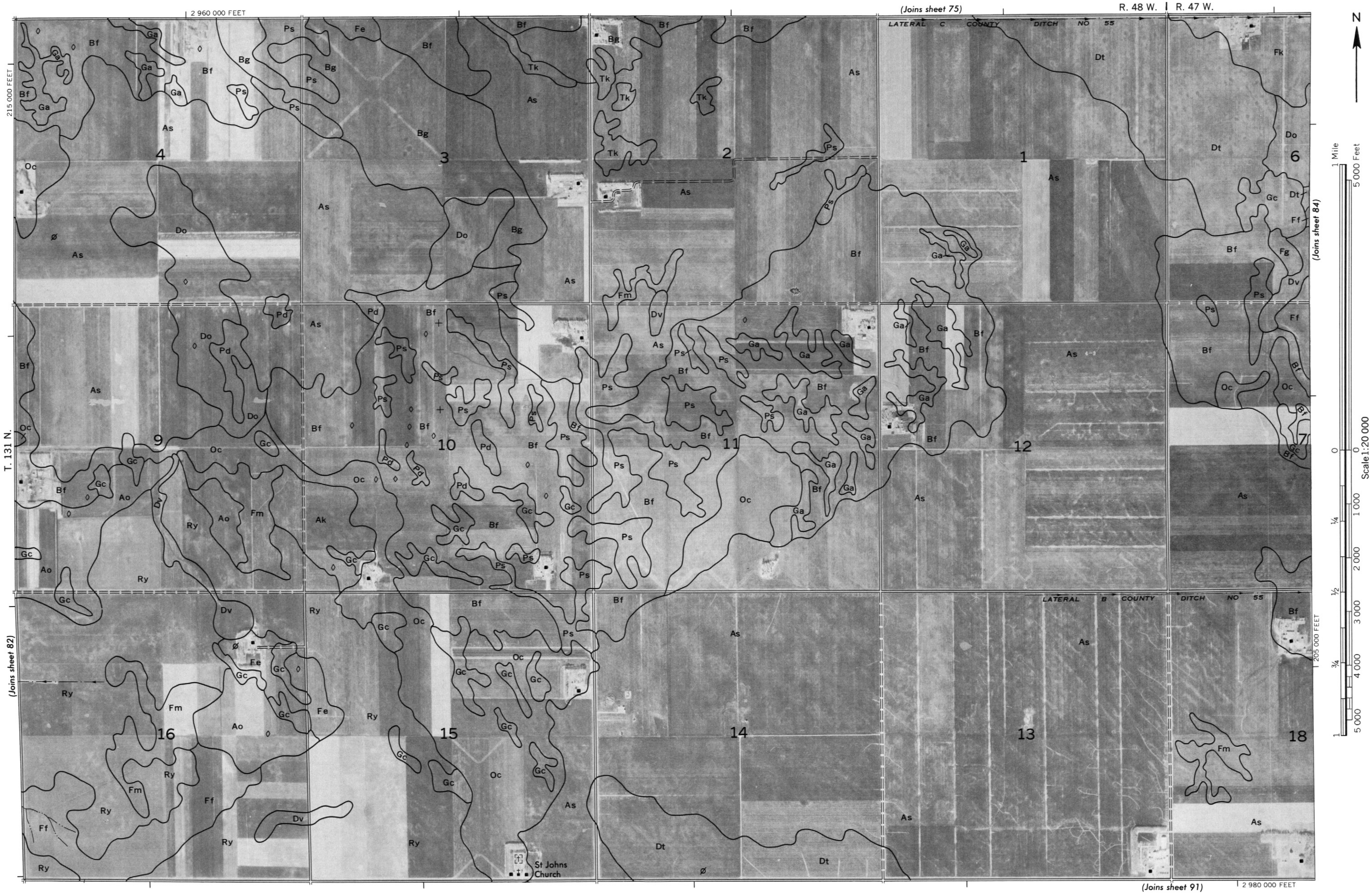
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 82

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 82

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

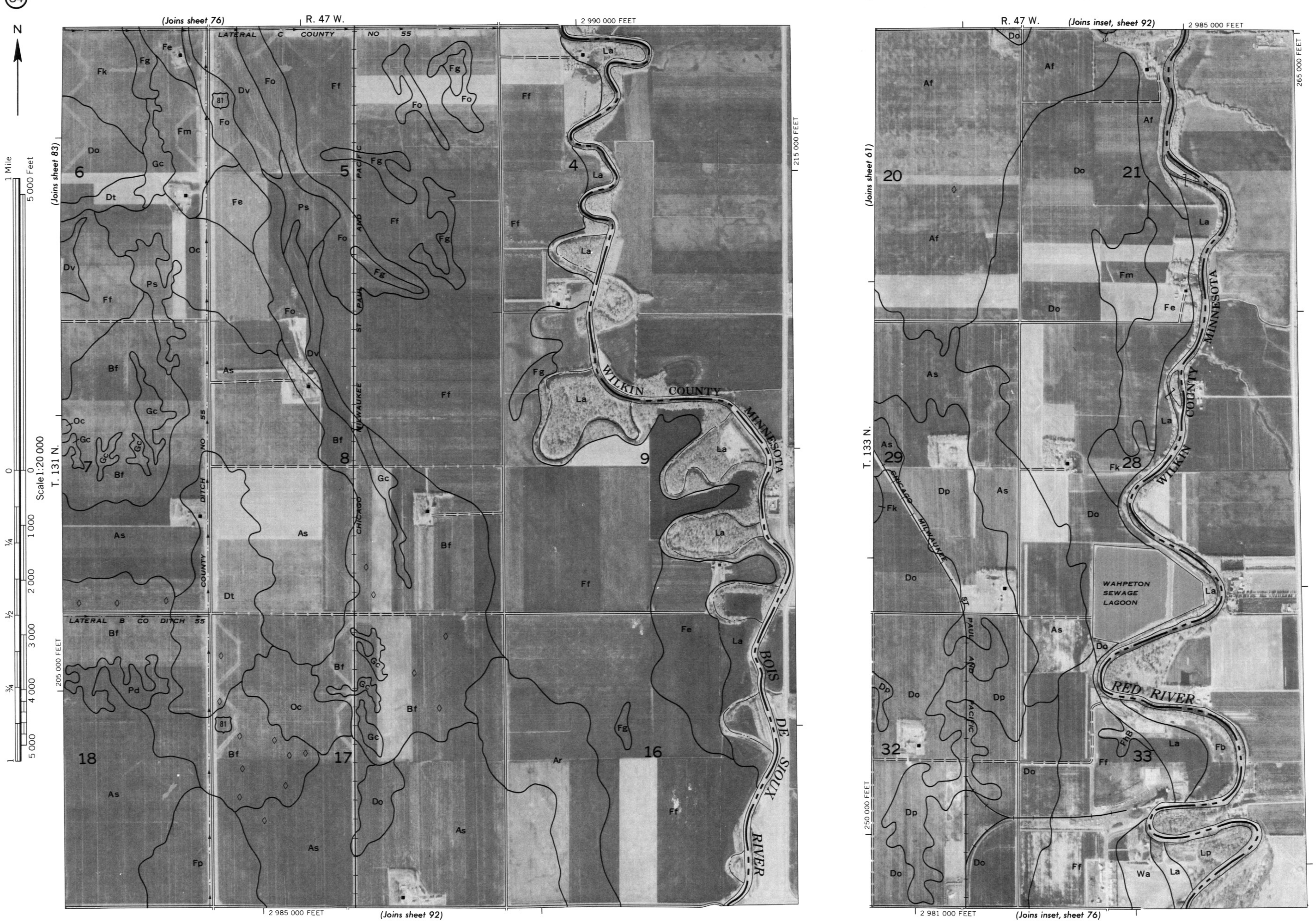
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 83

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 84



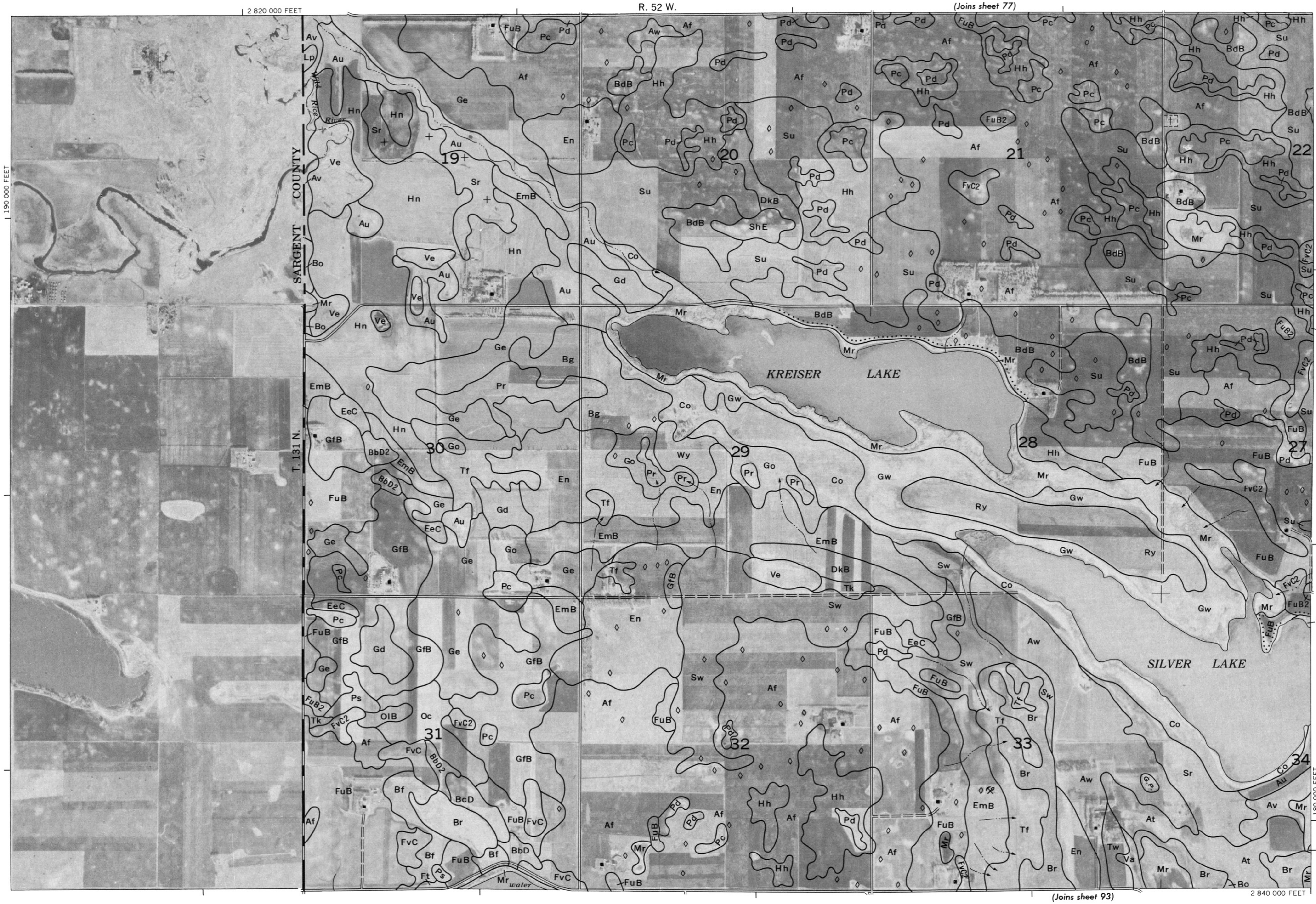
4000 AND 5000-FOOT GRID TICKS

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 84

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



N

Scale 1:20 000

0 ¼ ½ ¾ 1 Mile

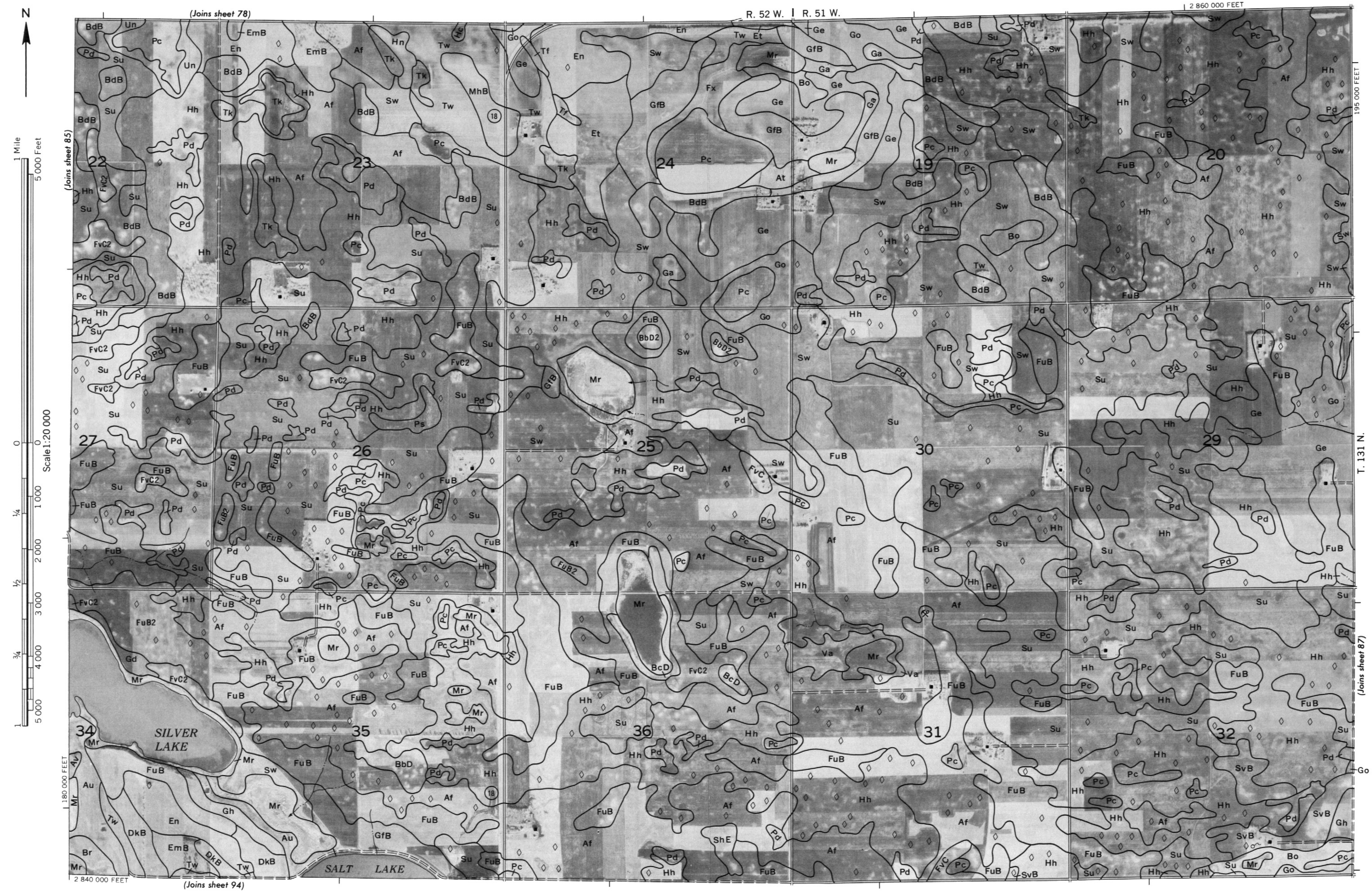
0 1000 2000 3000 4000 5000 Feet

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 86

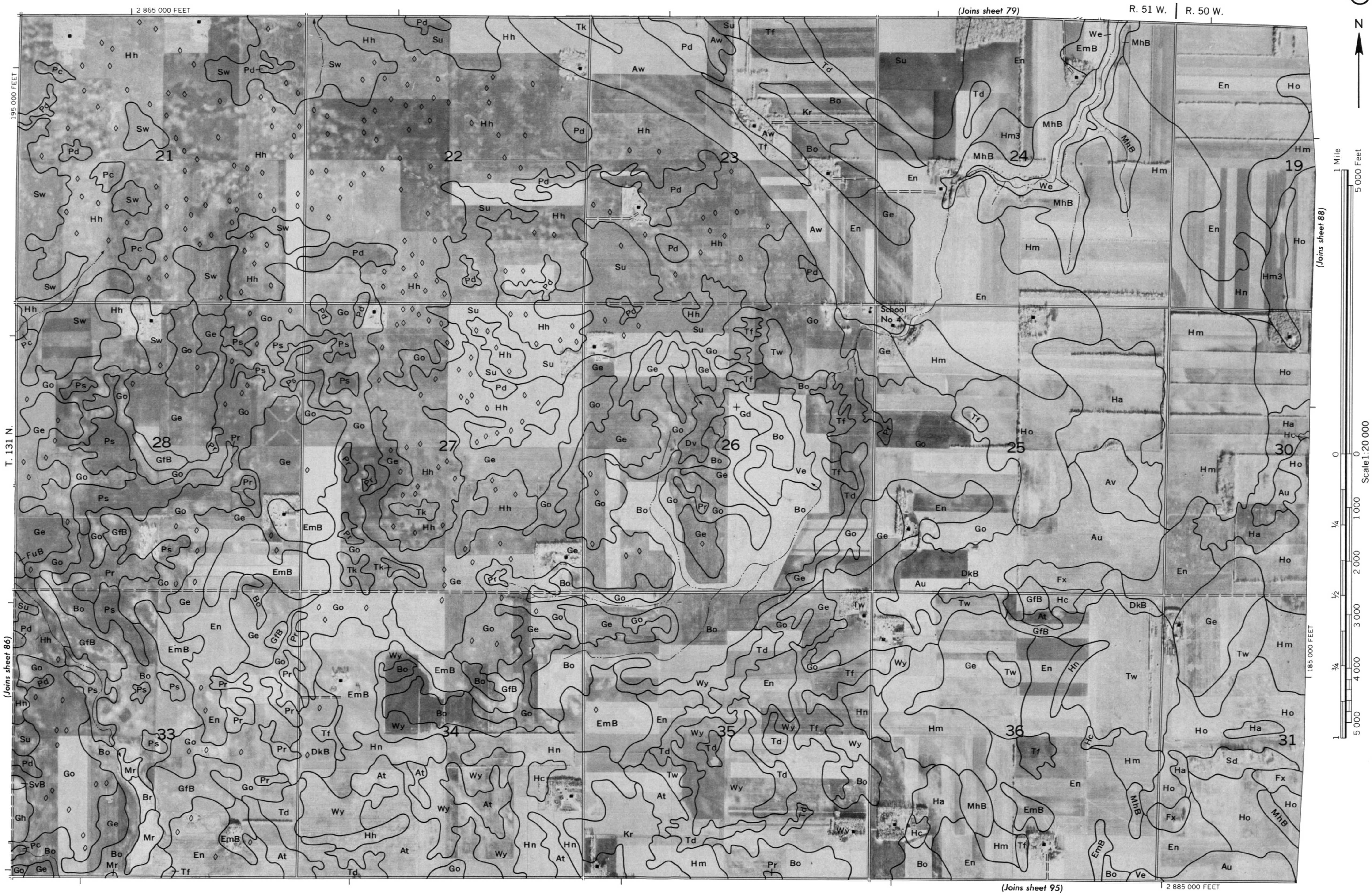


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 86

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

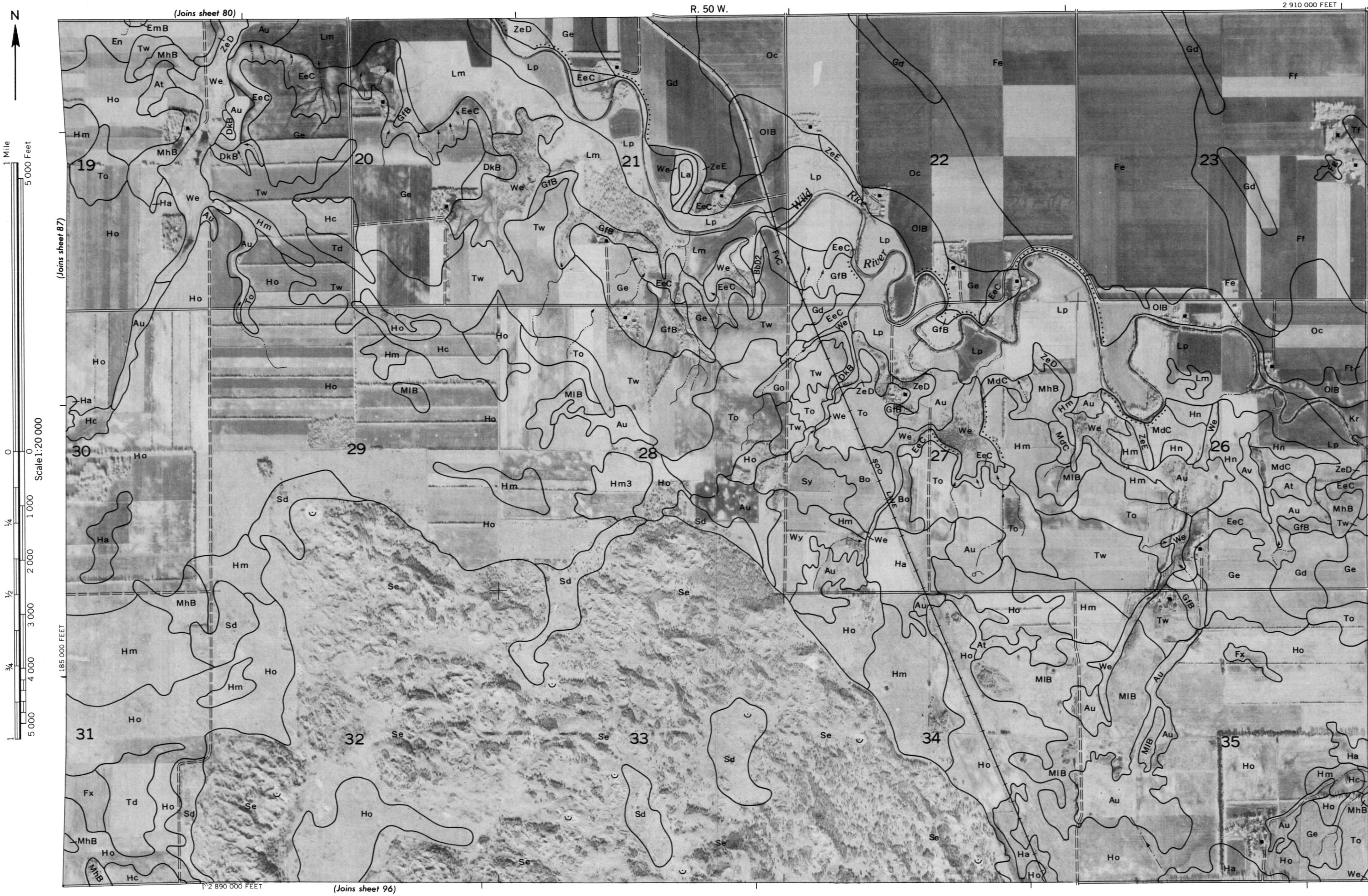
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 87

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 88



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 88

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 89

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 90

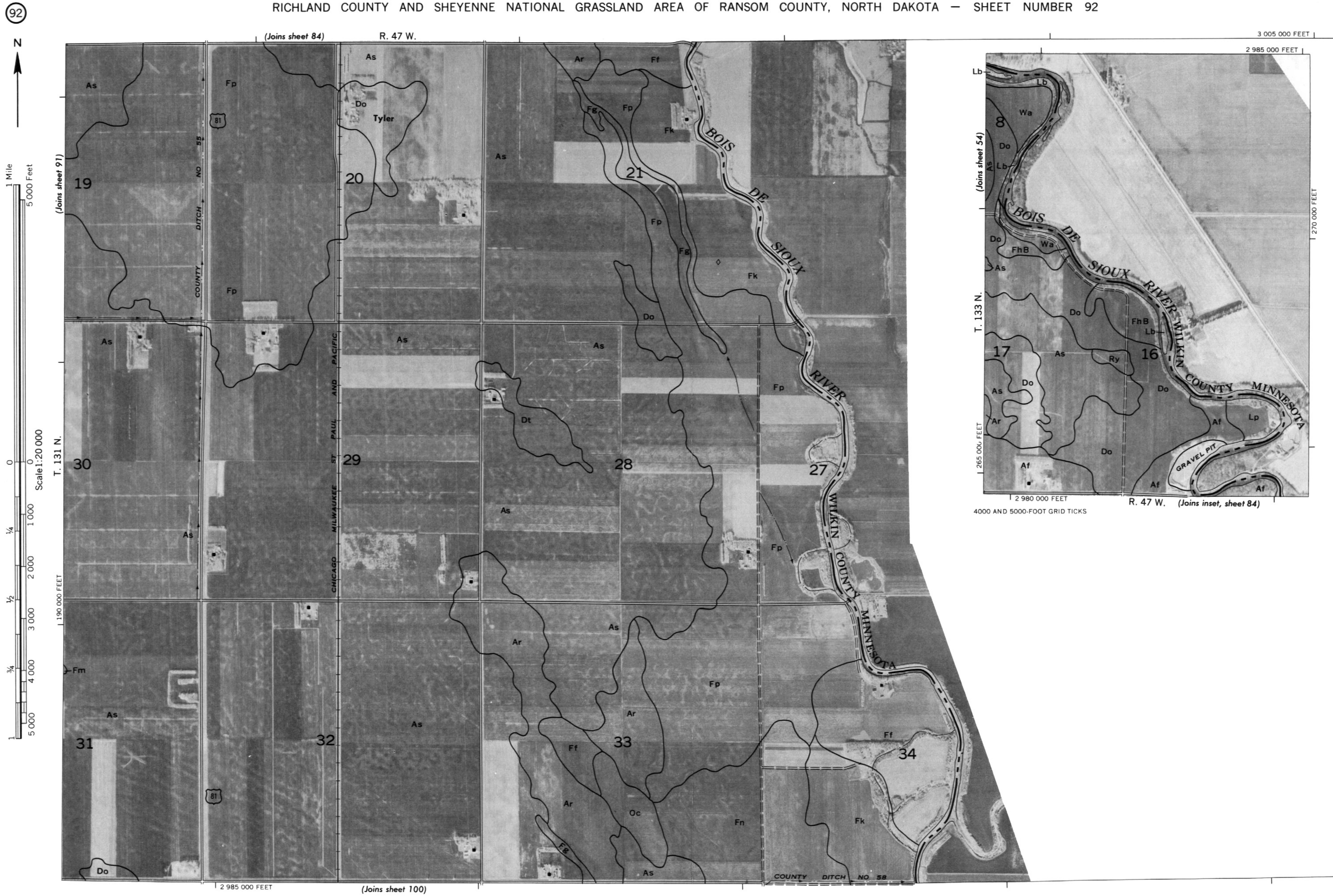
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 90

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 92

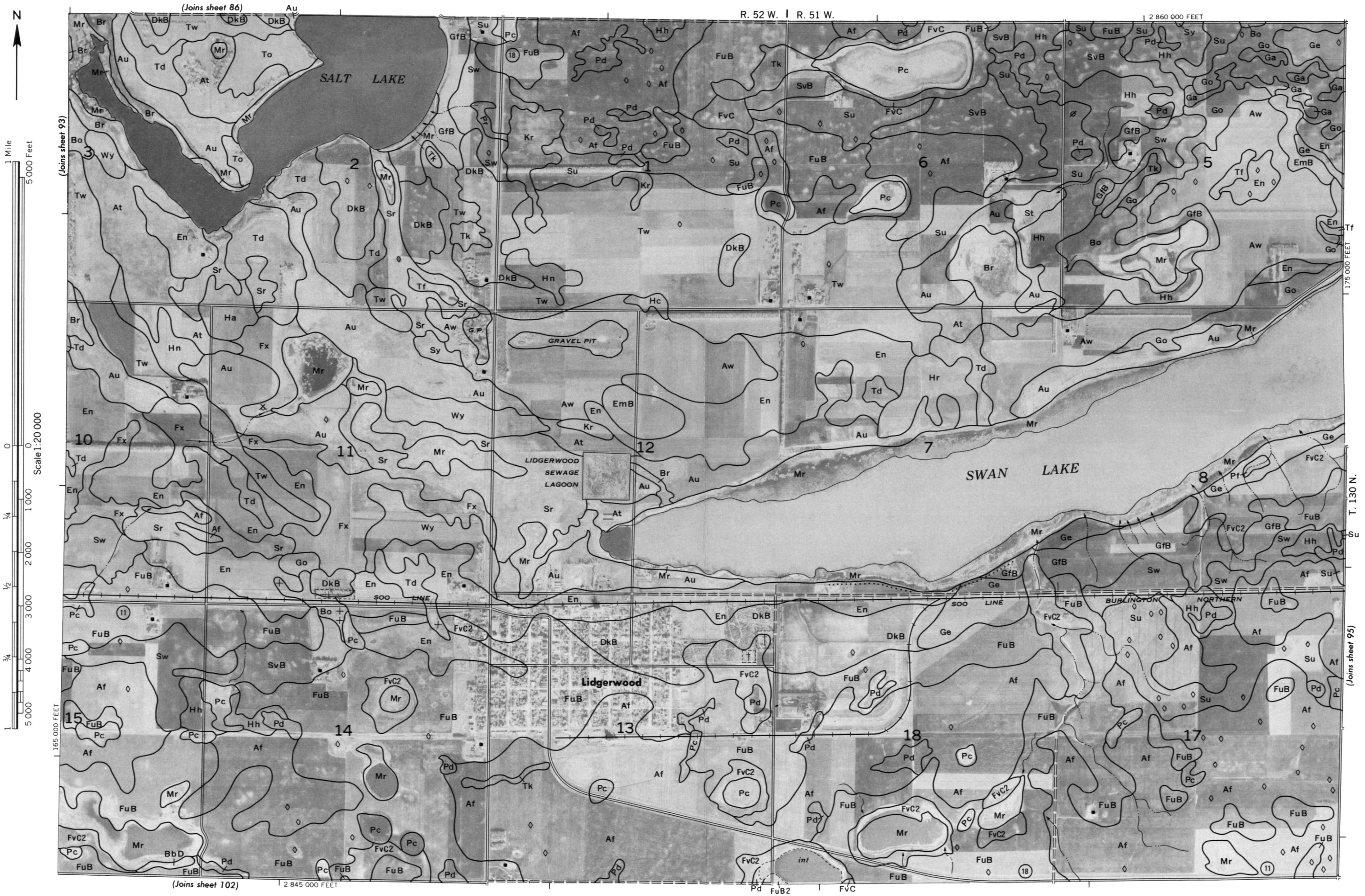
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 94

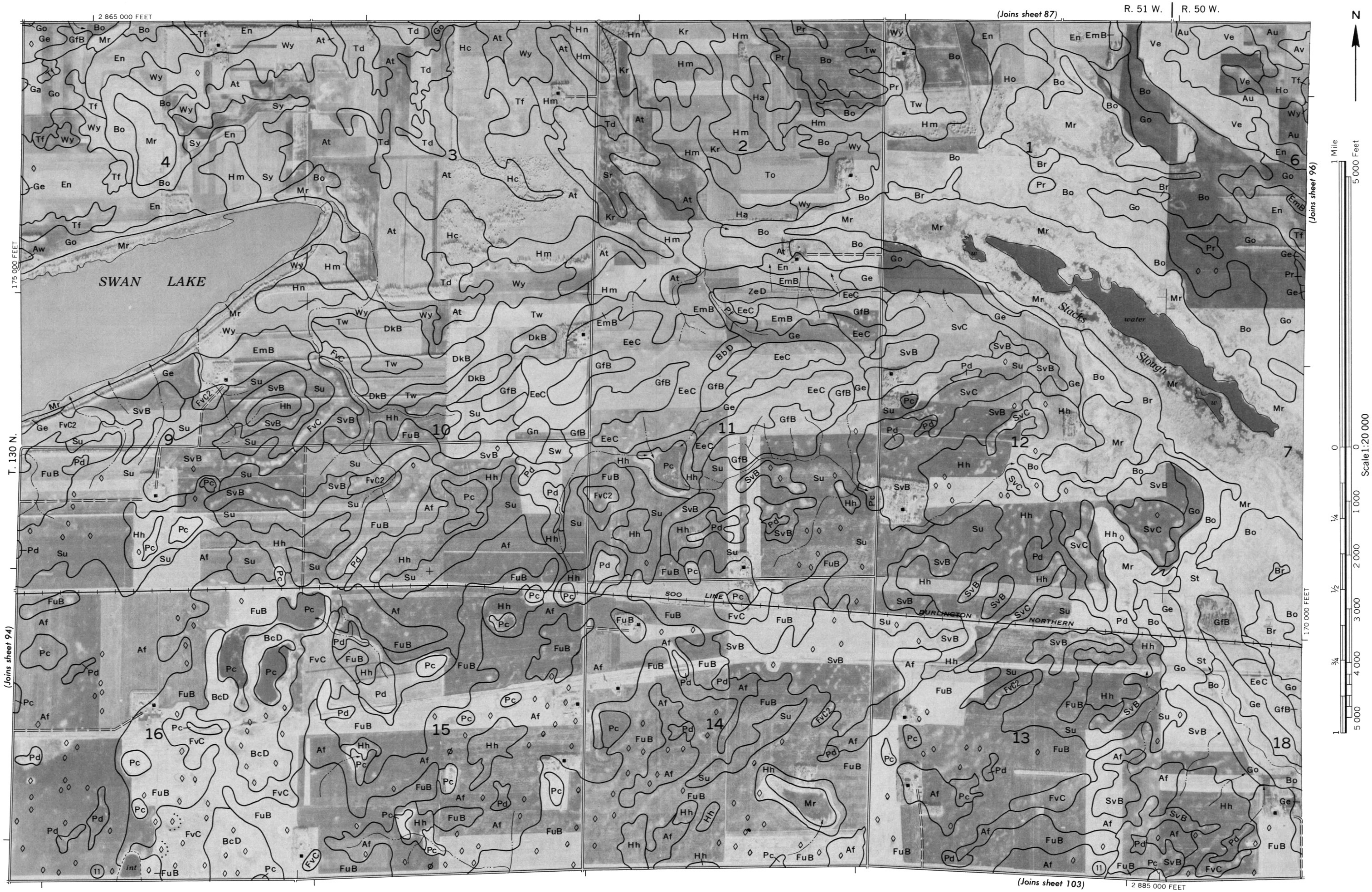


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 94

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

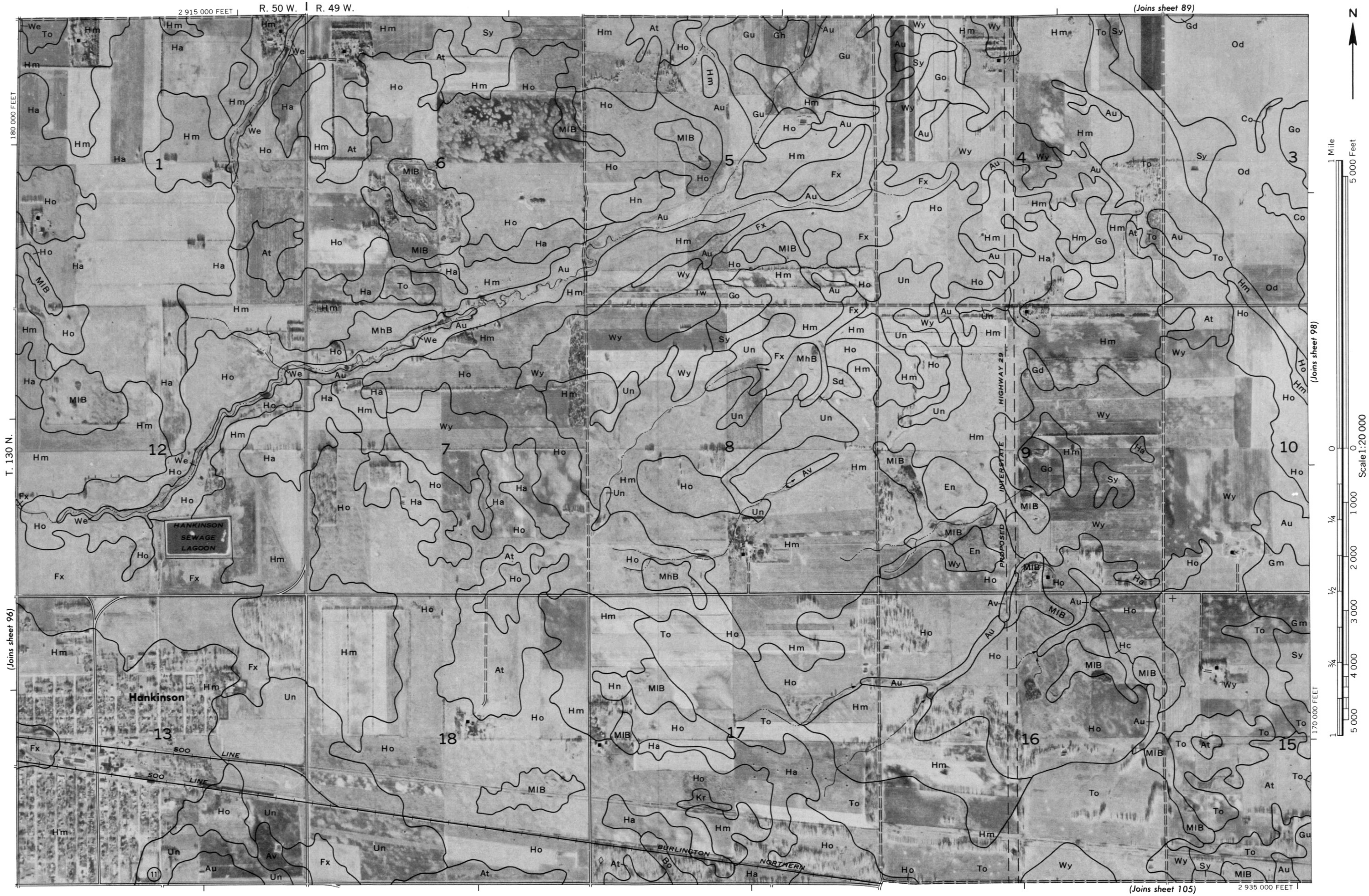
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 95

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 96

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

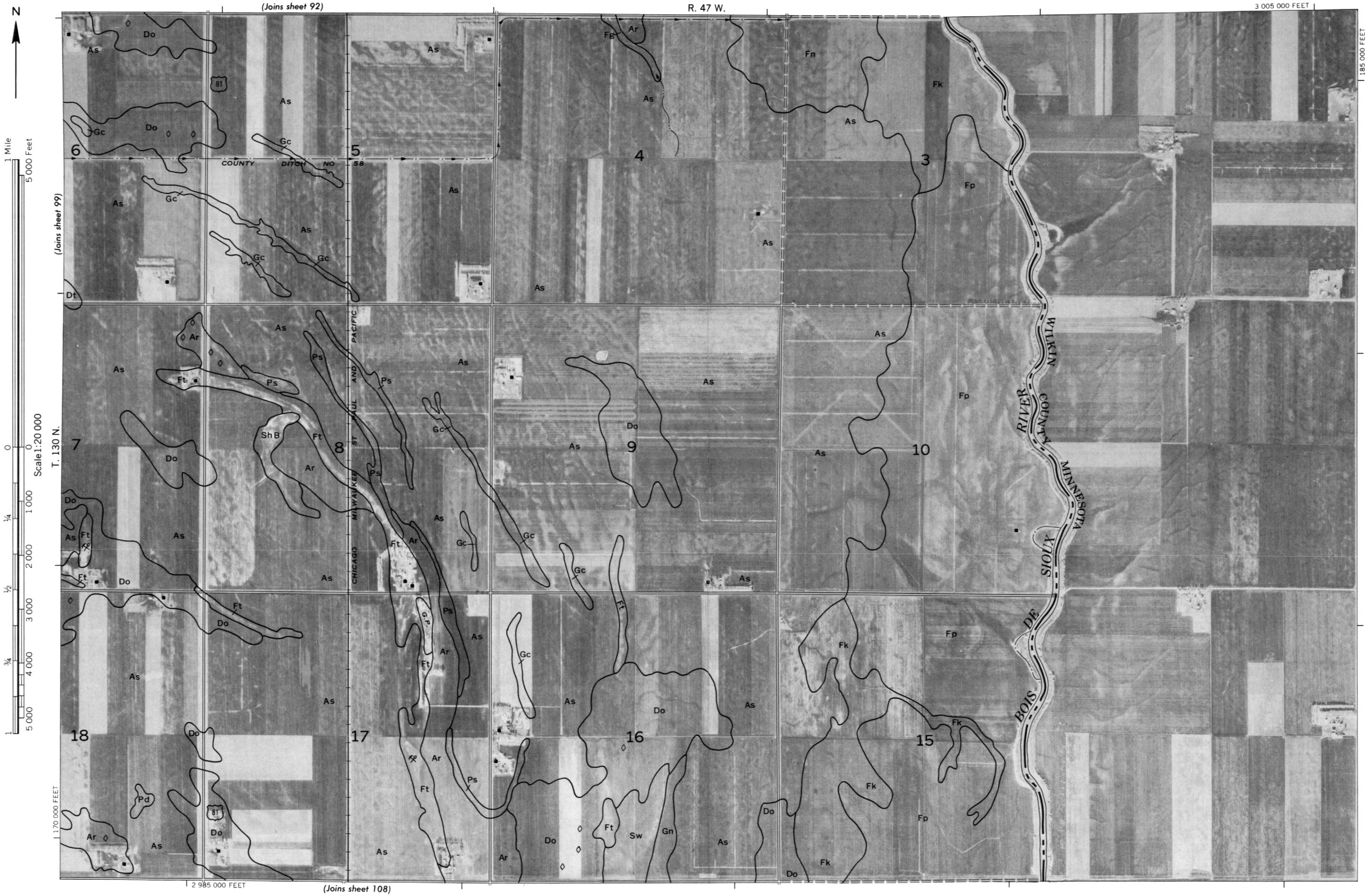
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 97

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 98

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 98
Land division corners are approximately positioned on this map.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 100



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 100

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

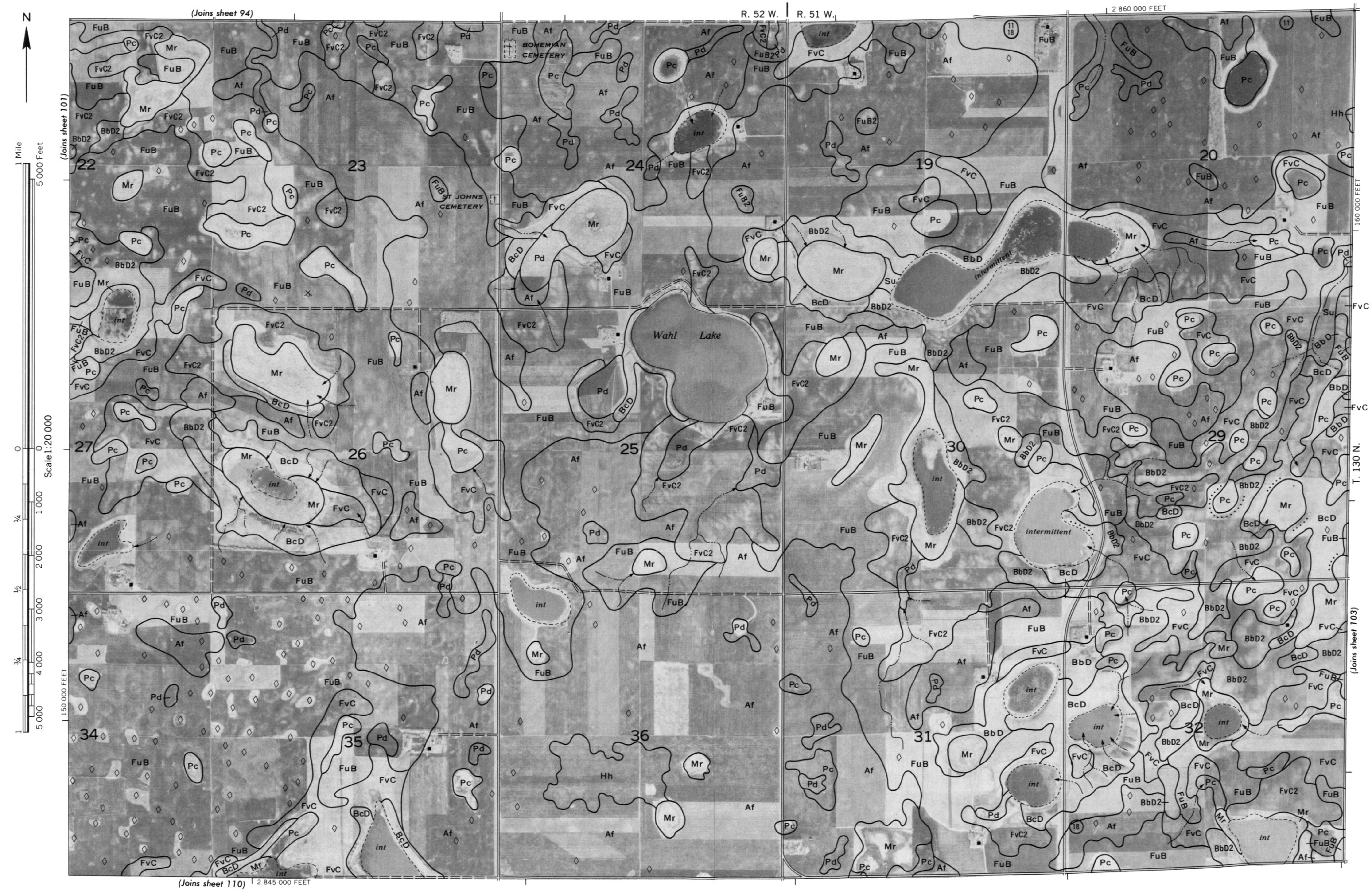
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

101

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 101

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 102



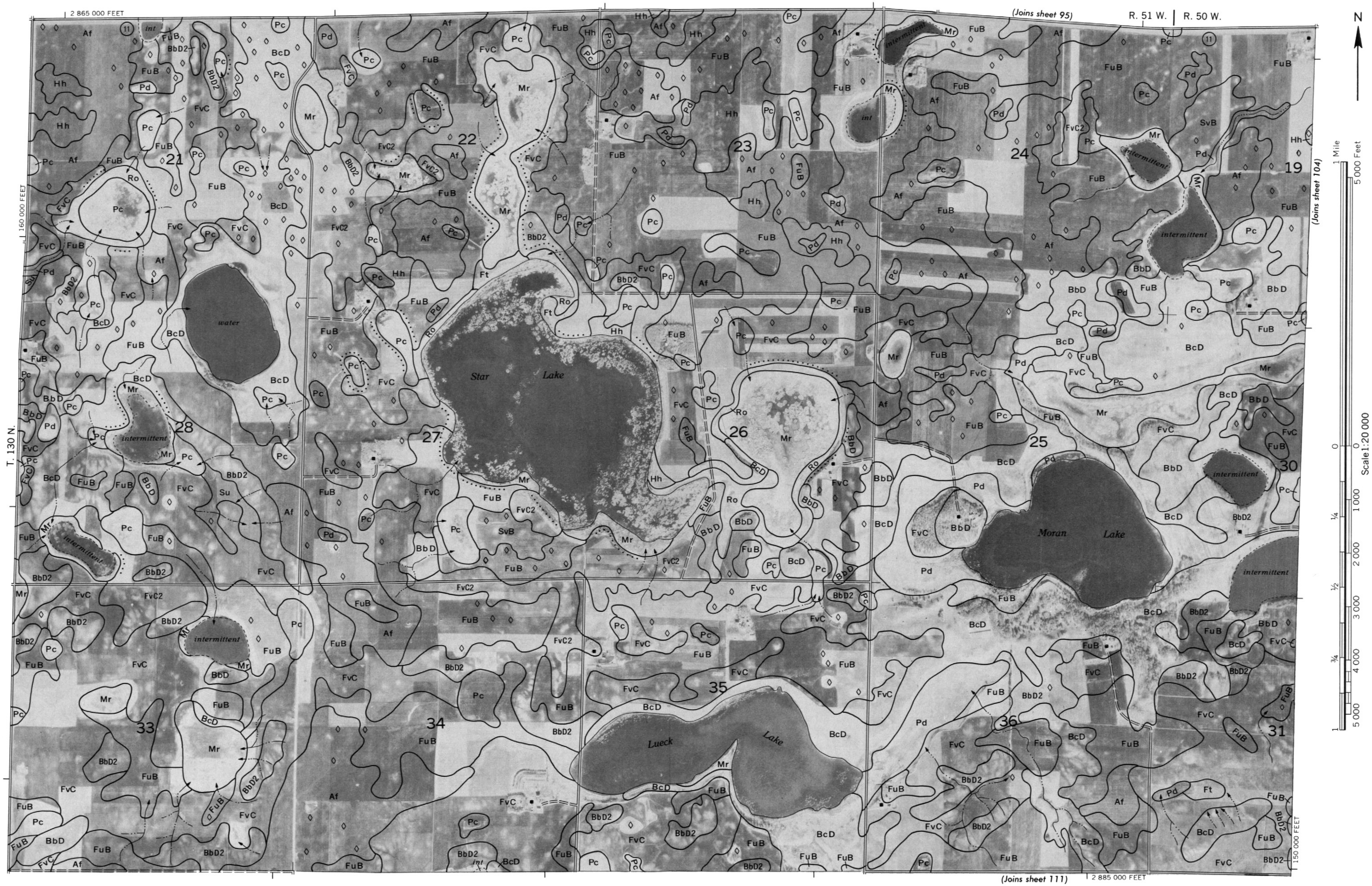
RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 102

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

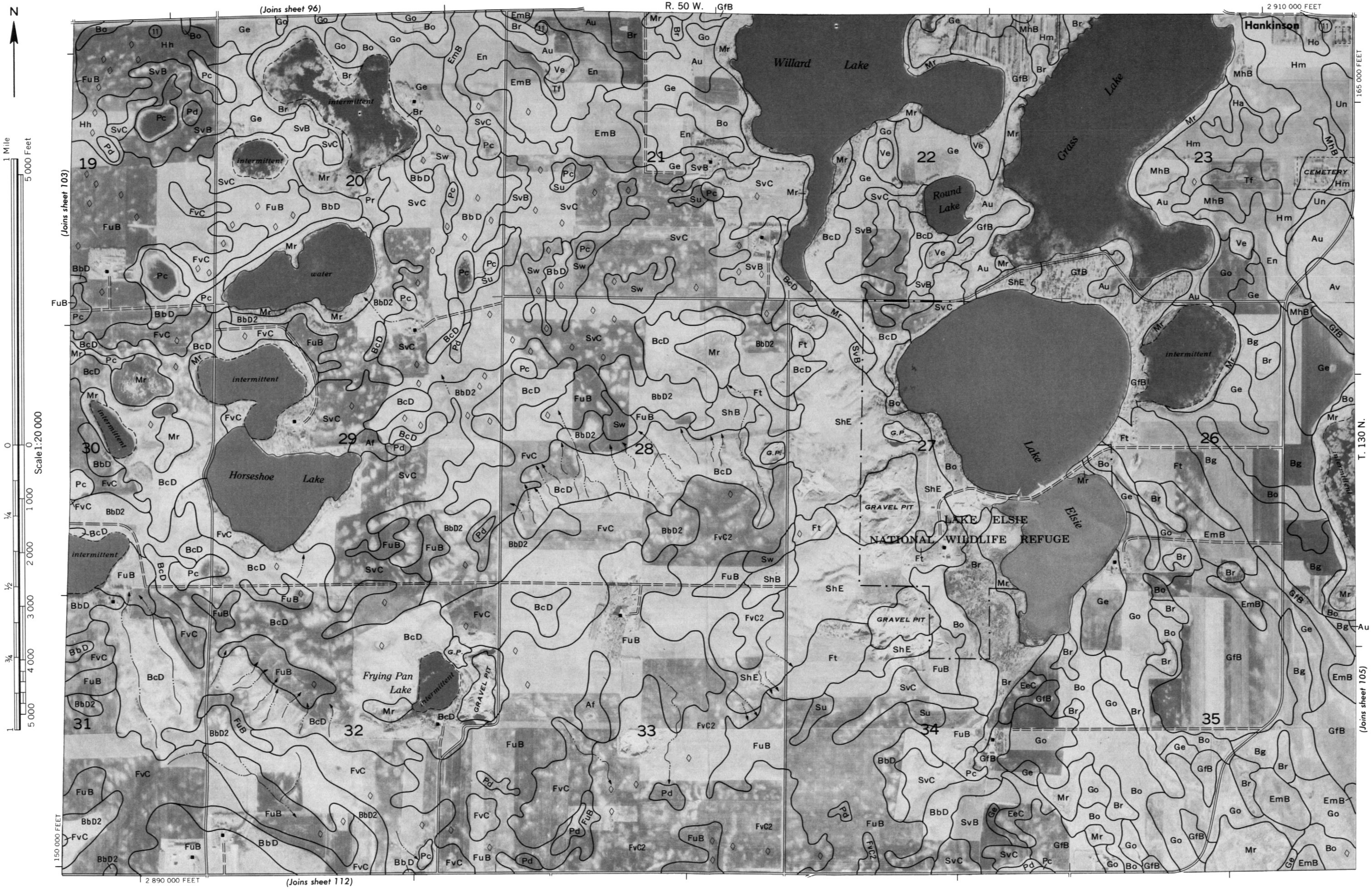
103



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 103

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station. Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone. Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 104

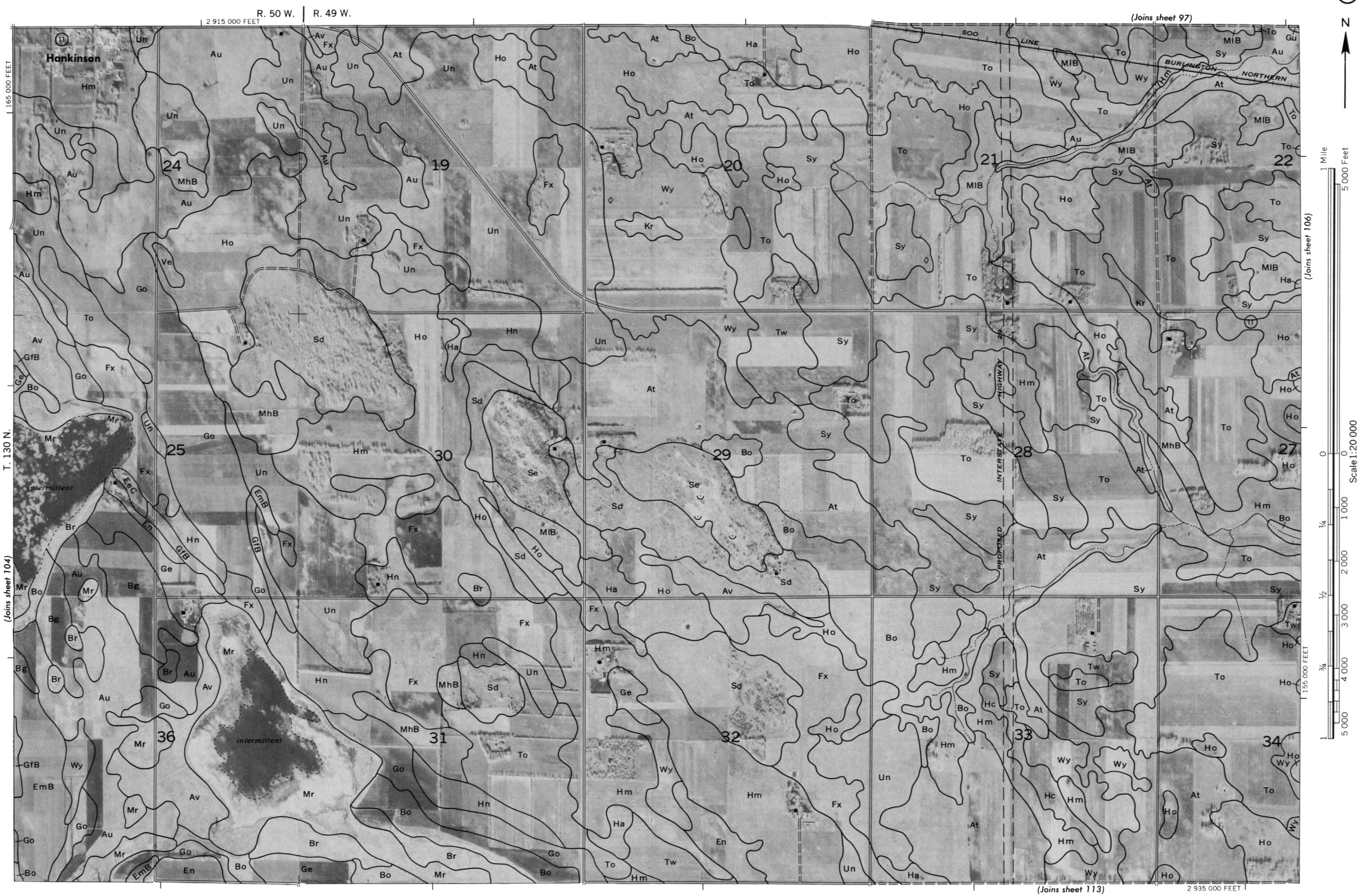


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 104

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

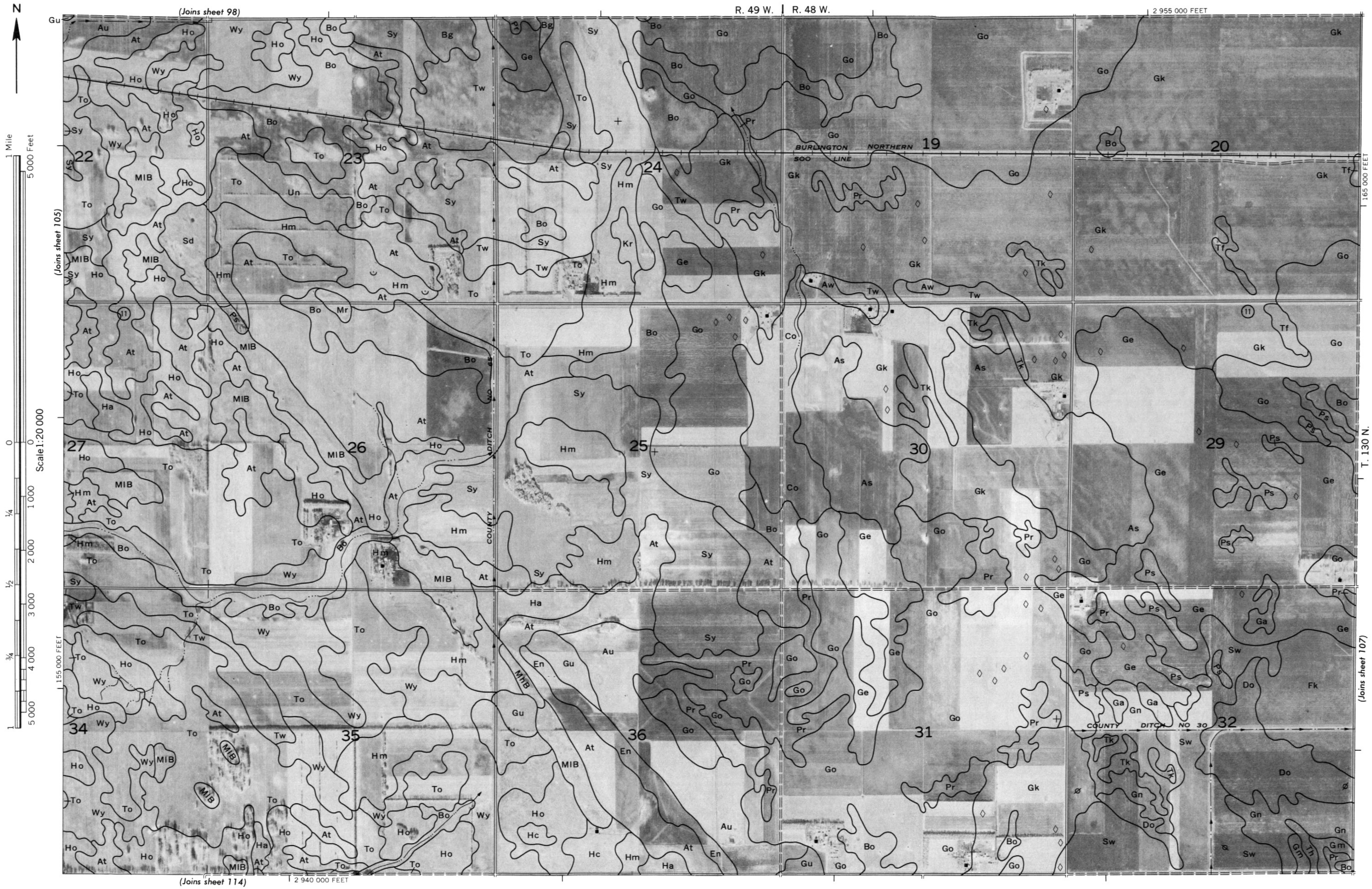
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 105

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 106

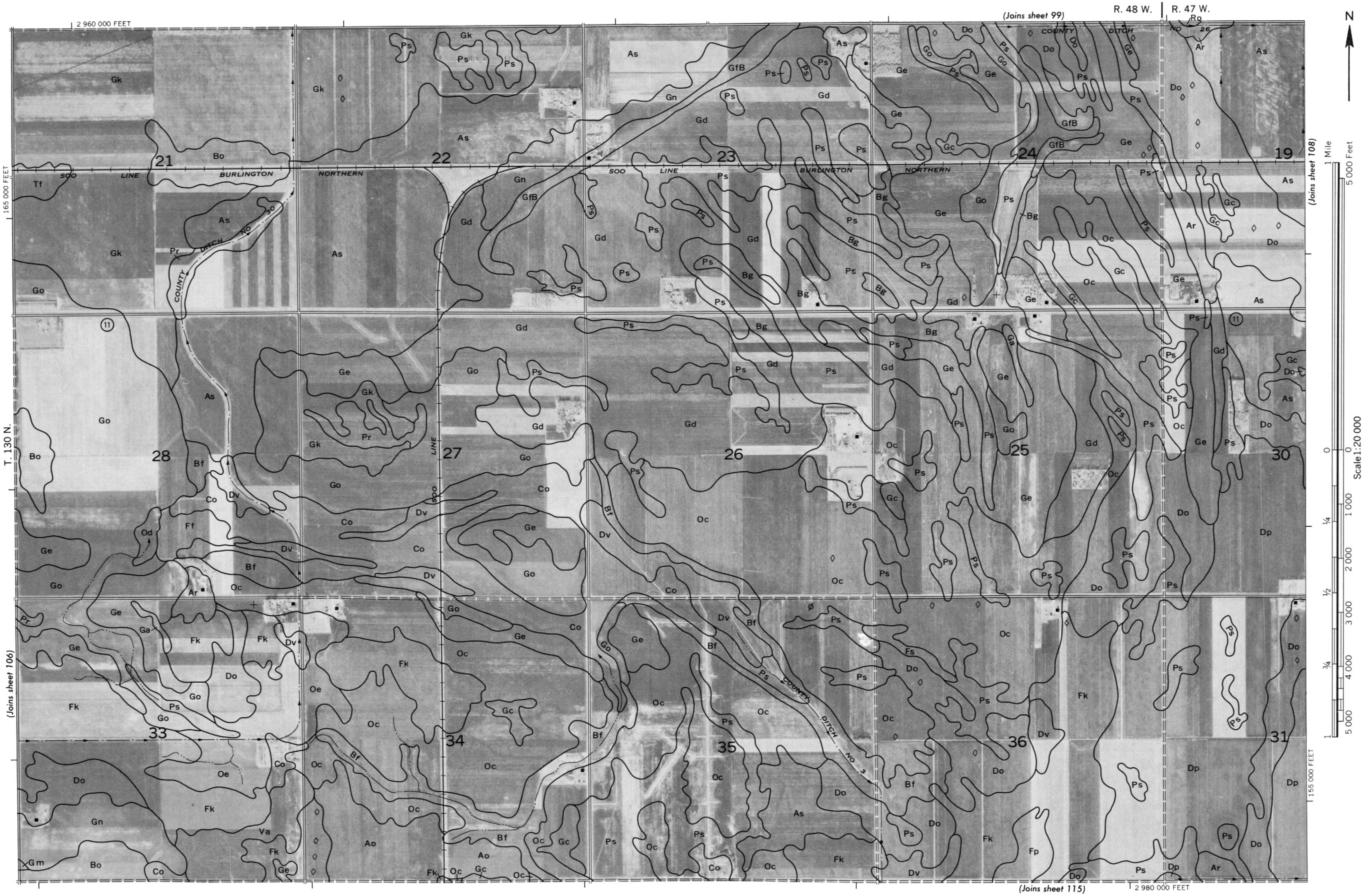


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 106

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 107

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 108

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 108

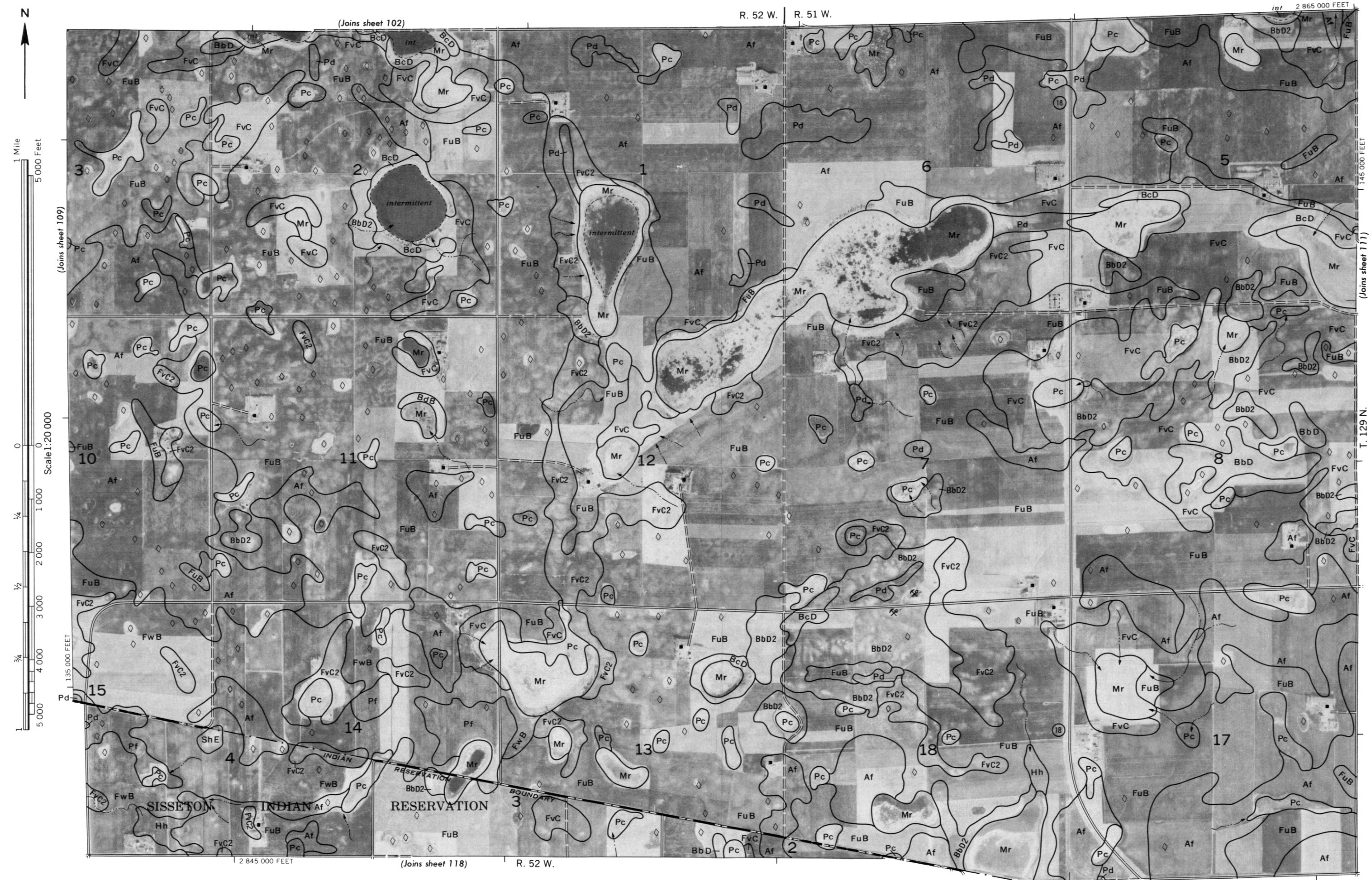
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

109

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 110

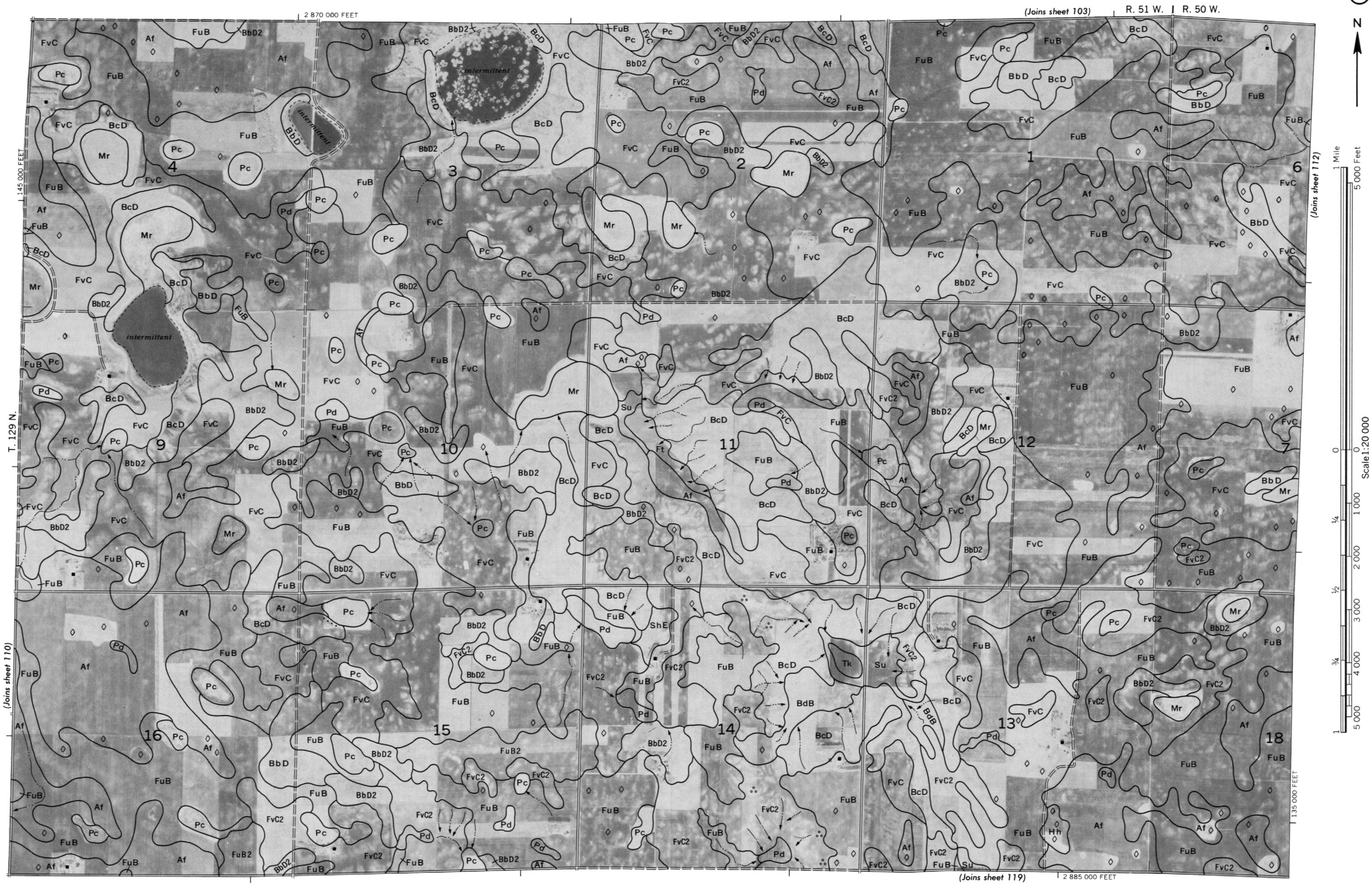
Land division corners are approximately positioned on this map.

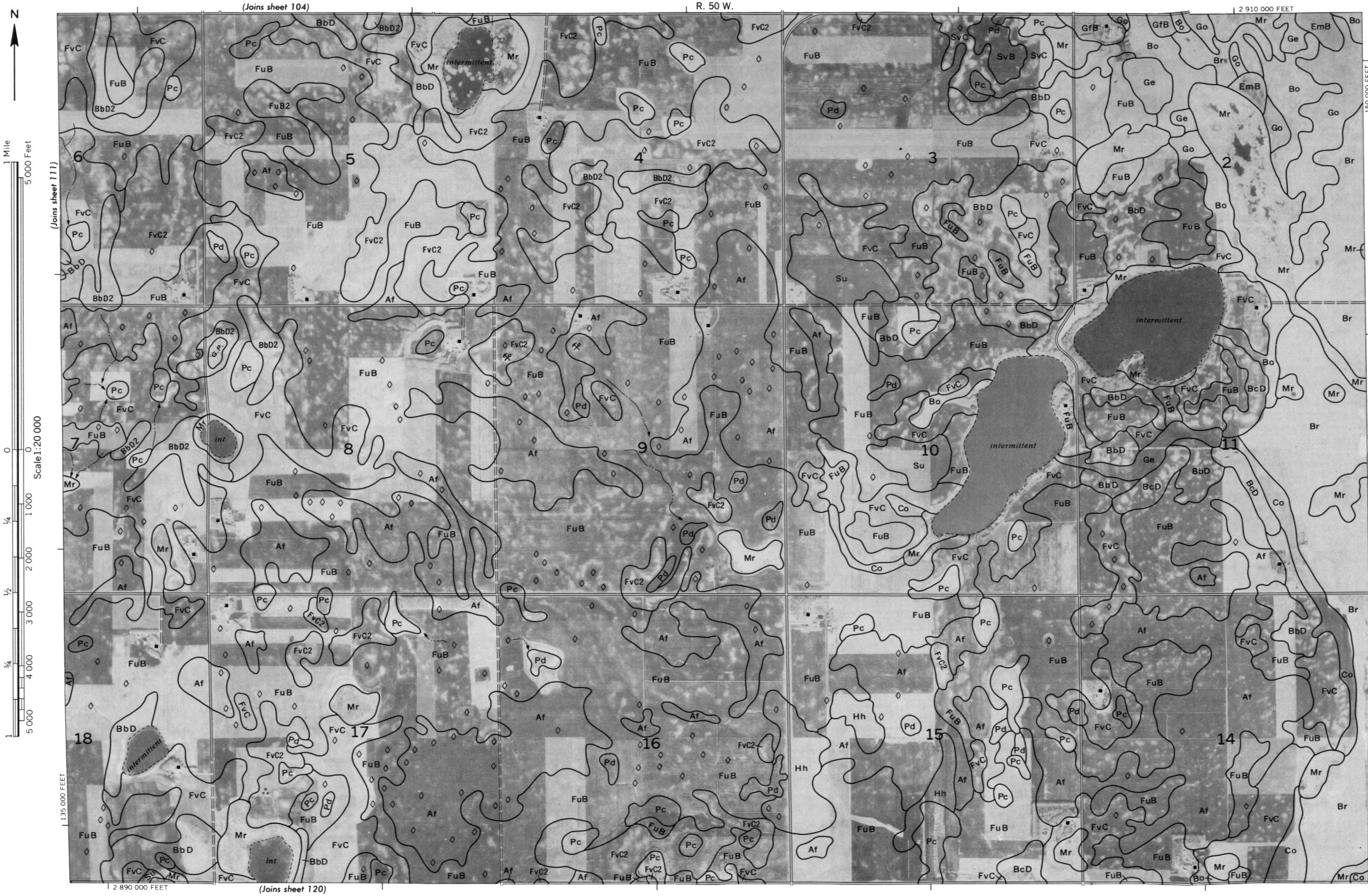
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 111



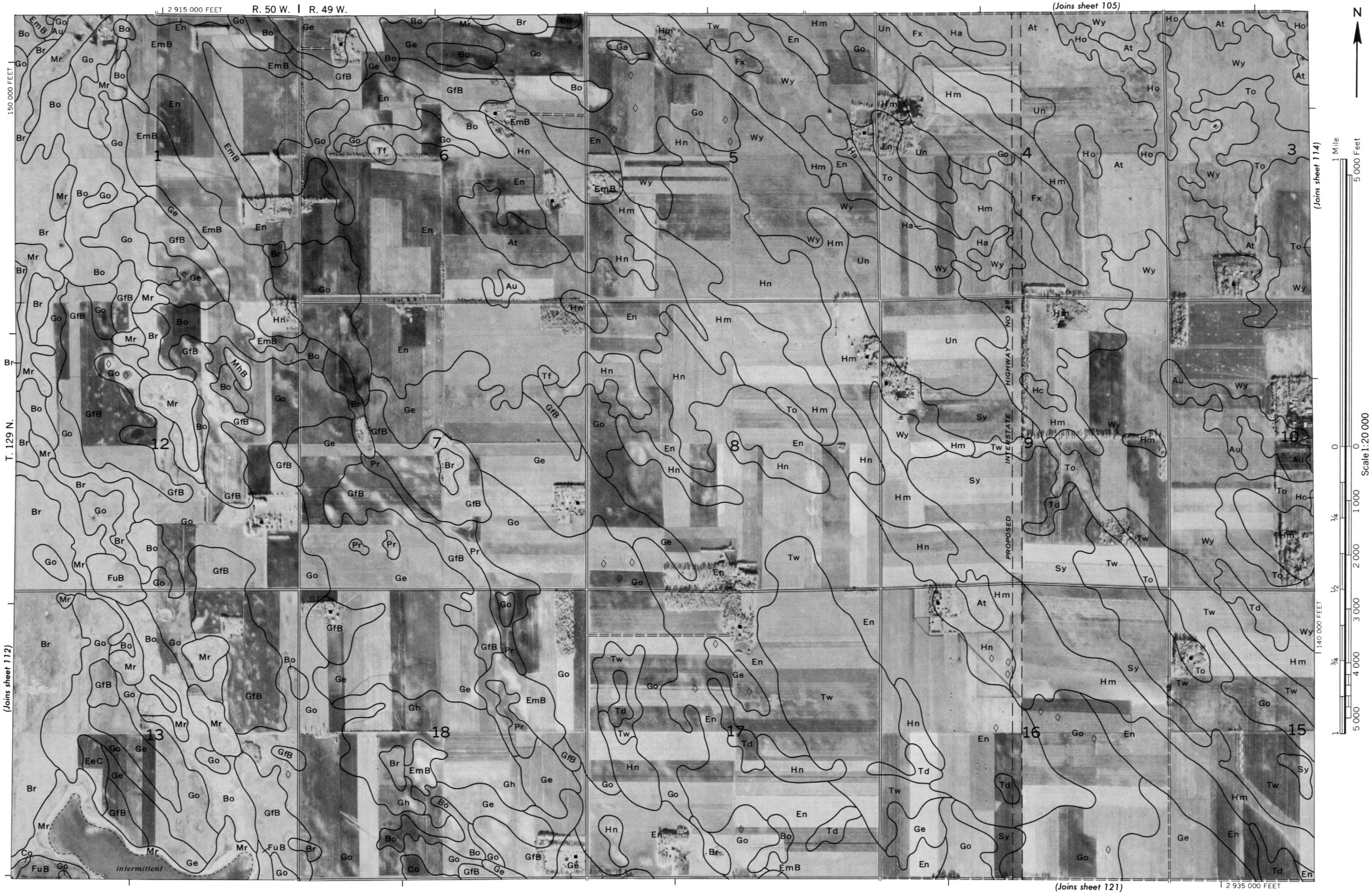


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 112

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

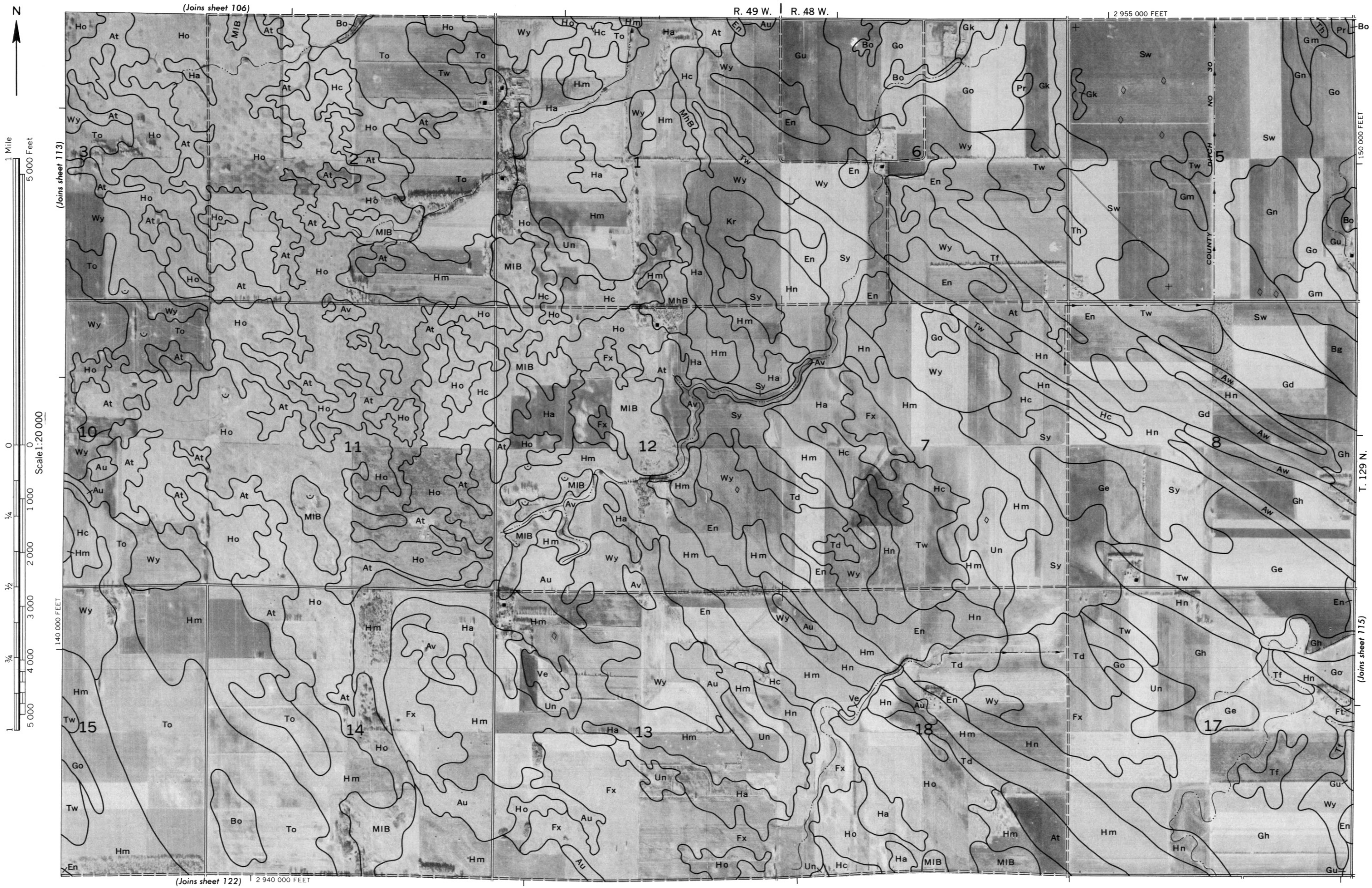
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 113

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 114

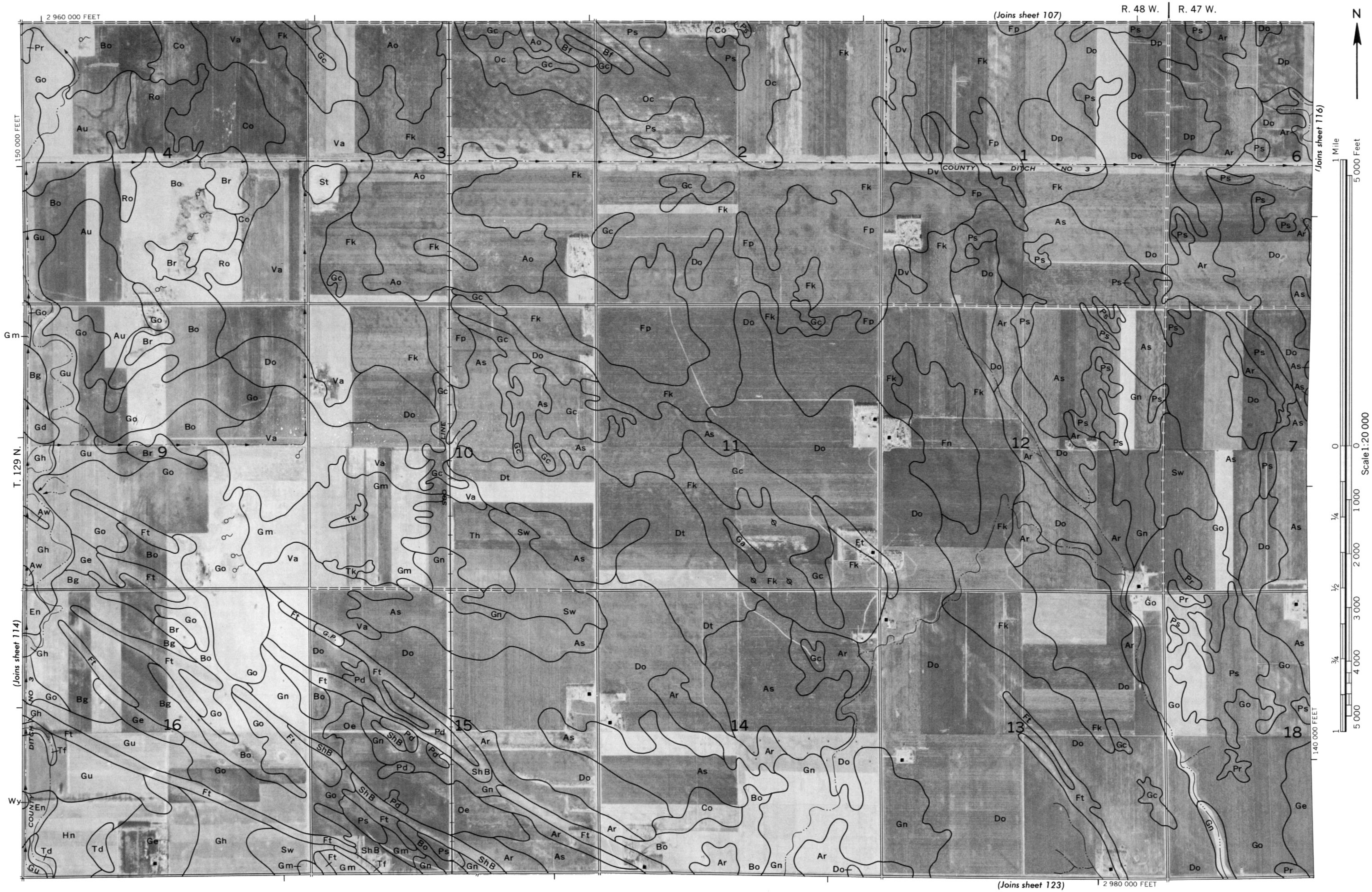


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 114

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 115

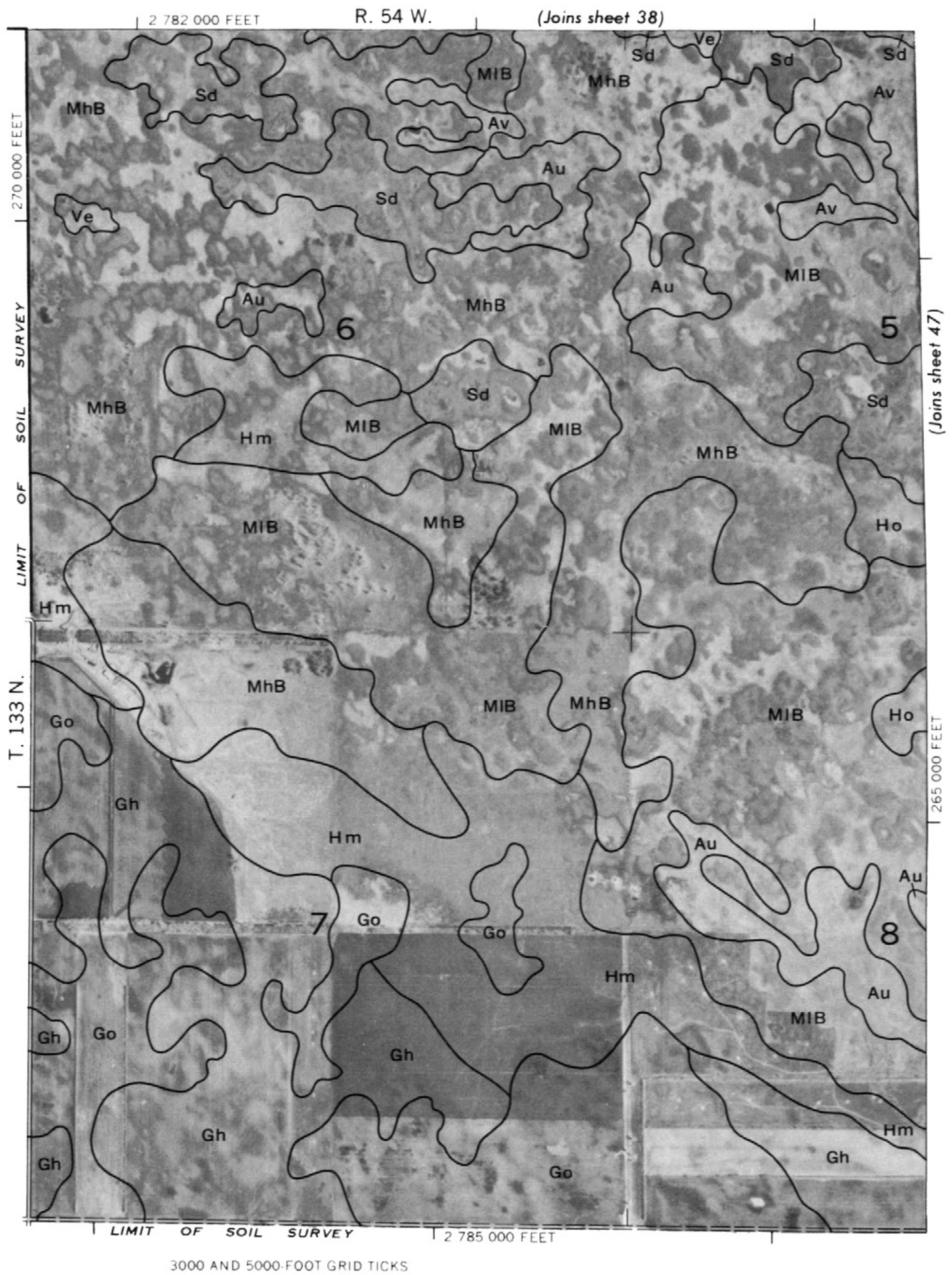
RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 116

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 116

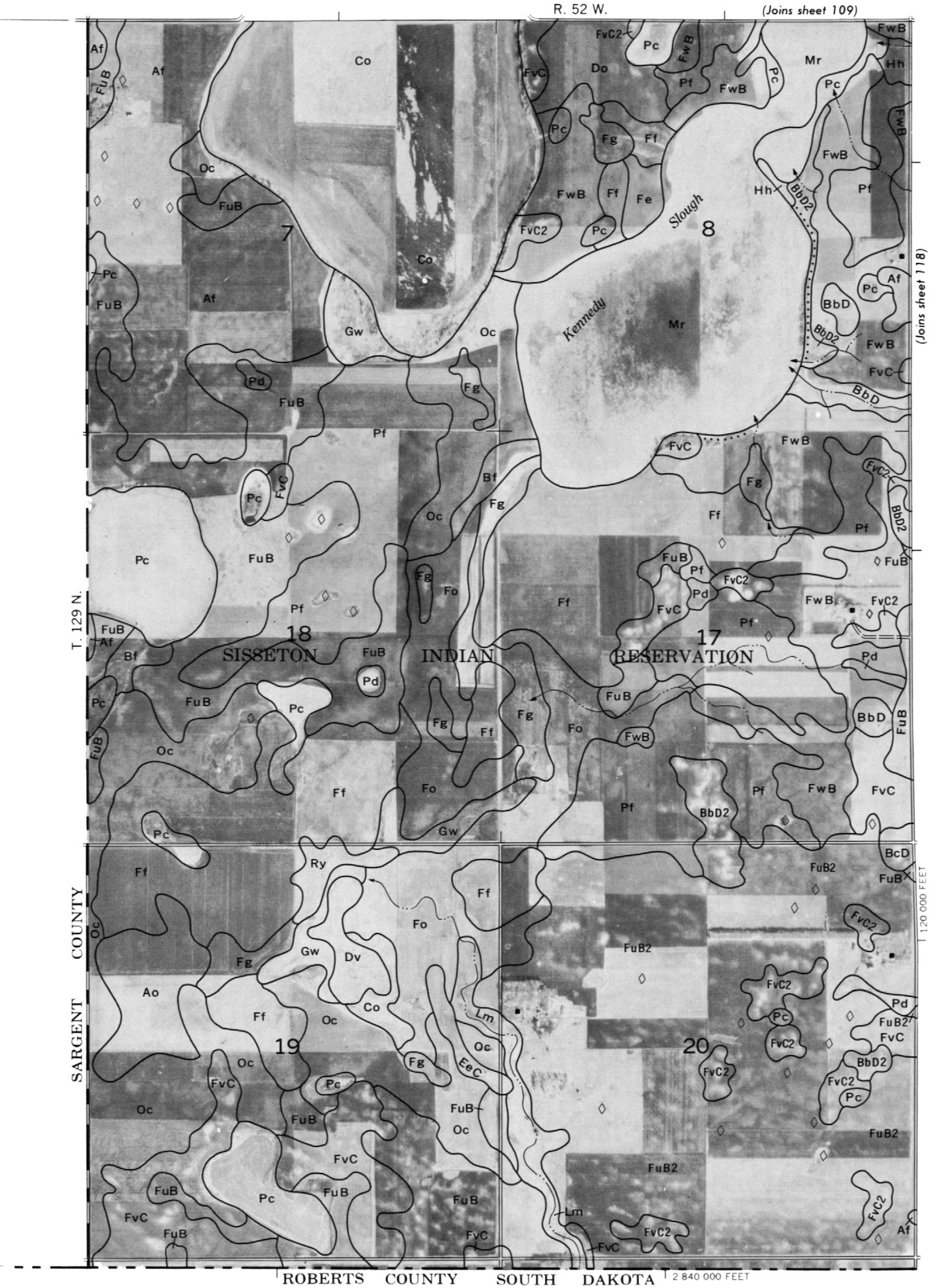
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



3000 AND 5000-FOOT GRID TICKS



N

Scale 1:20 000

1 Mile

5 000 Feet

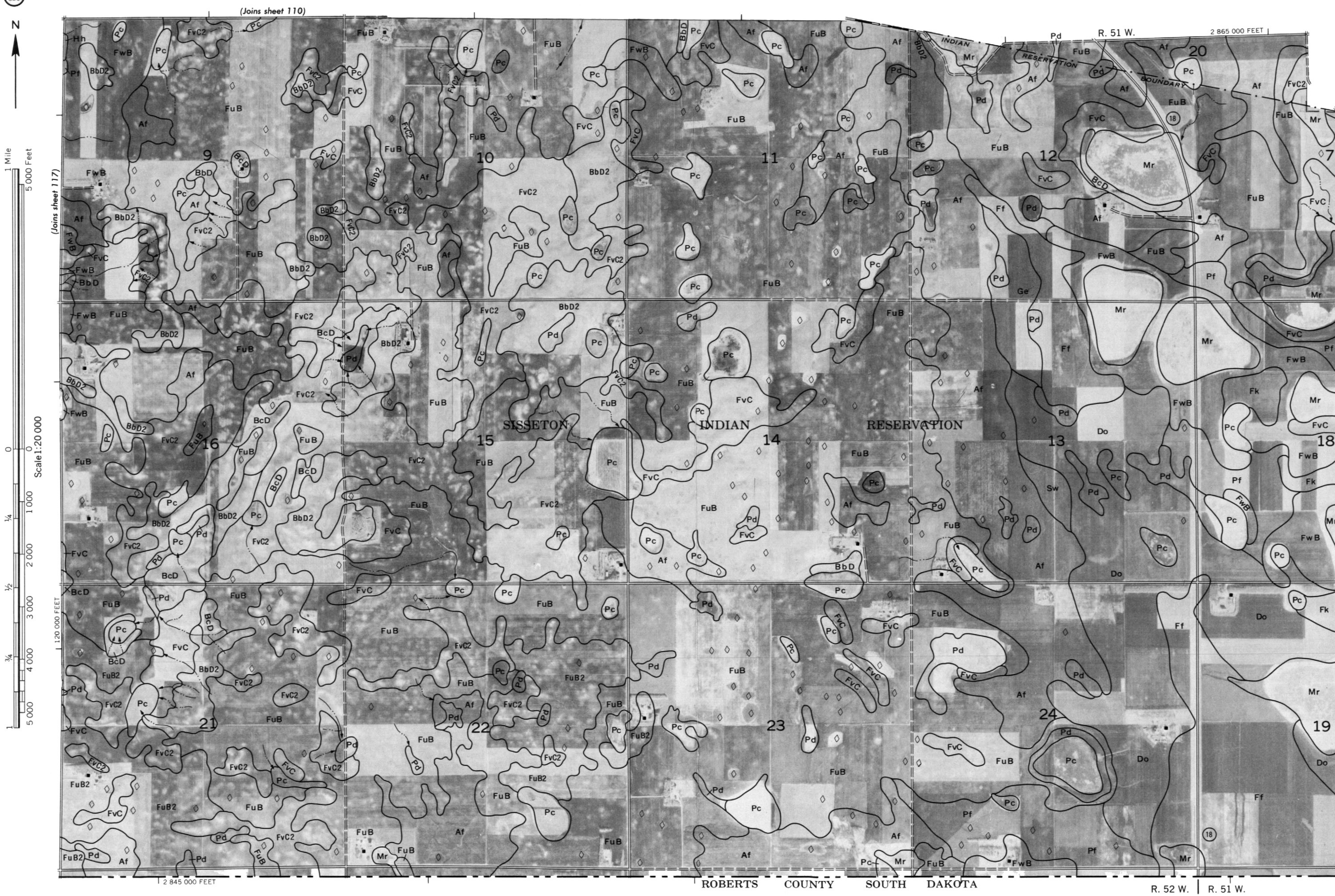
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 117

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 118

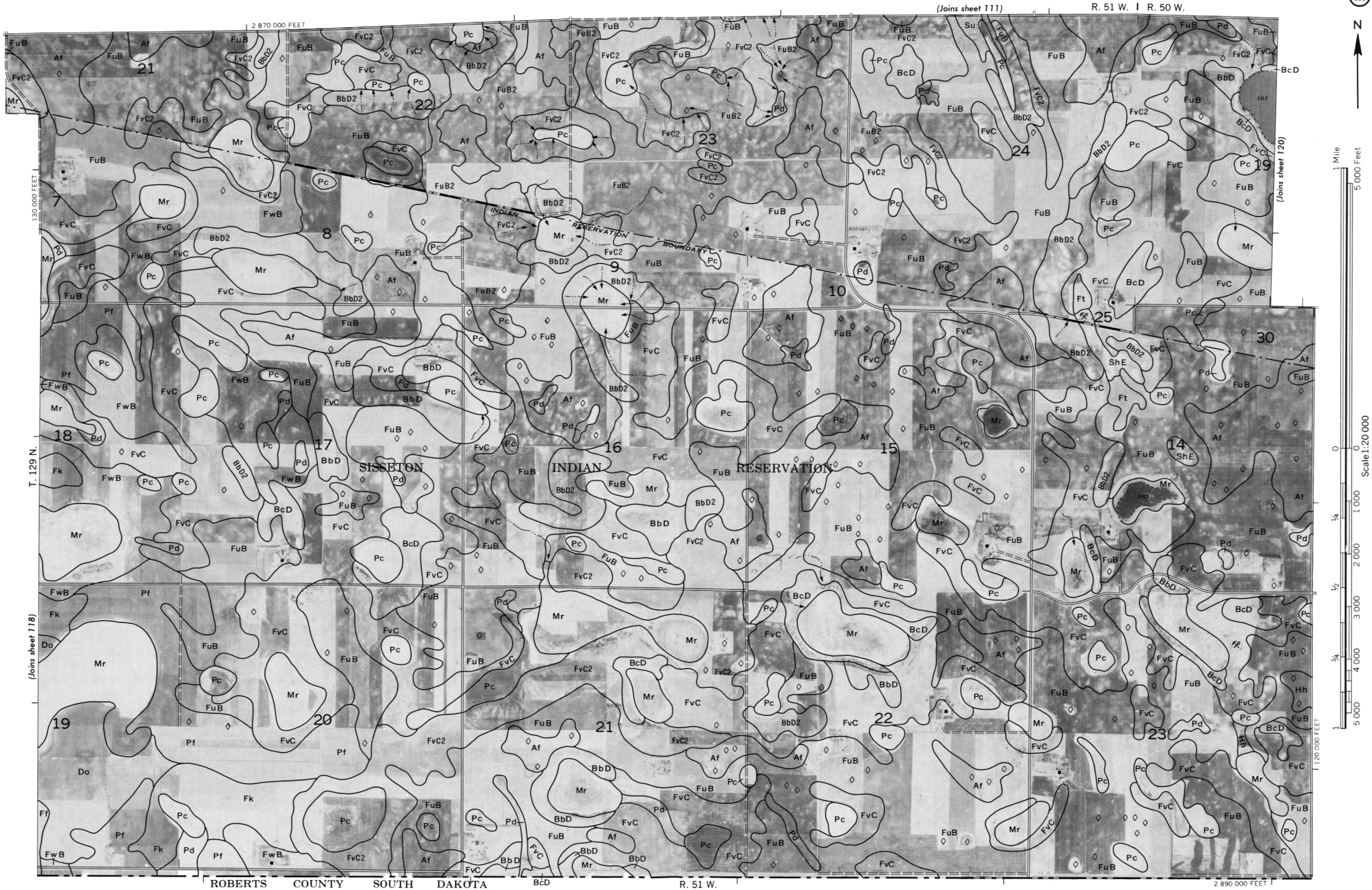


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 118

Land division corners are approximately positioned on this map.

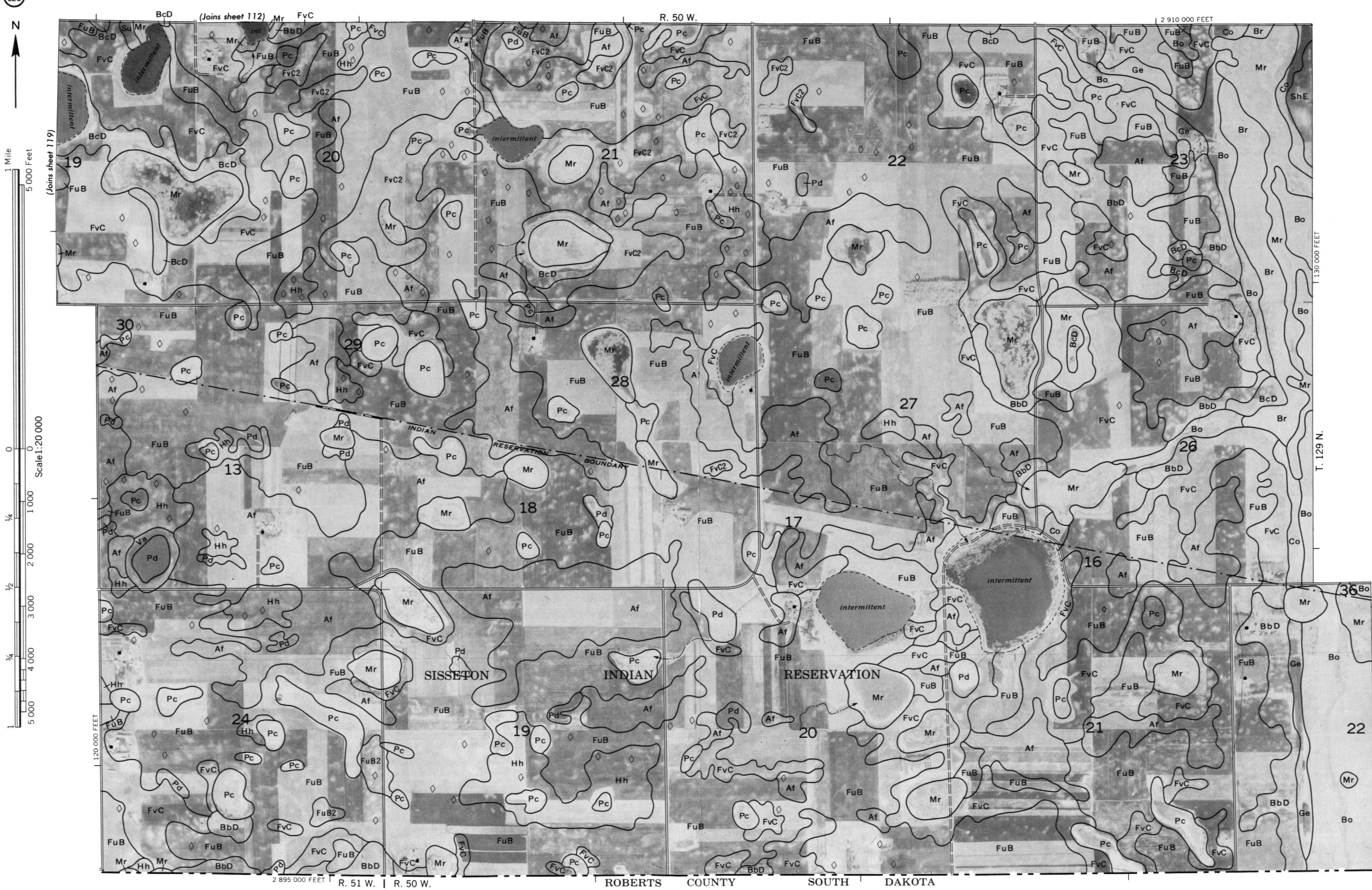
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 119

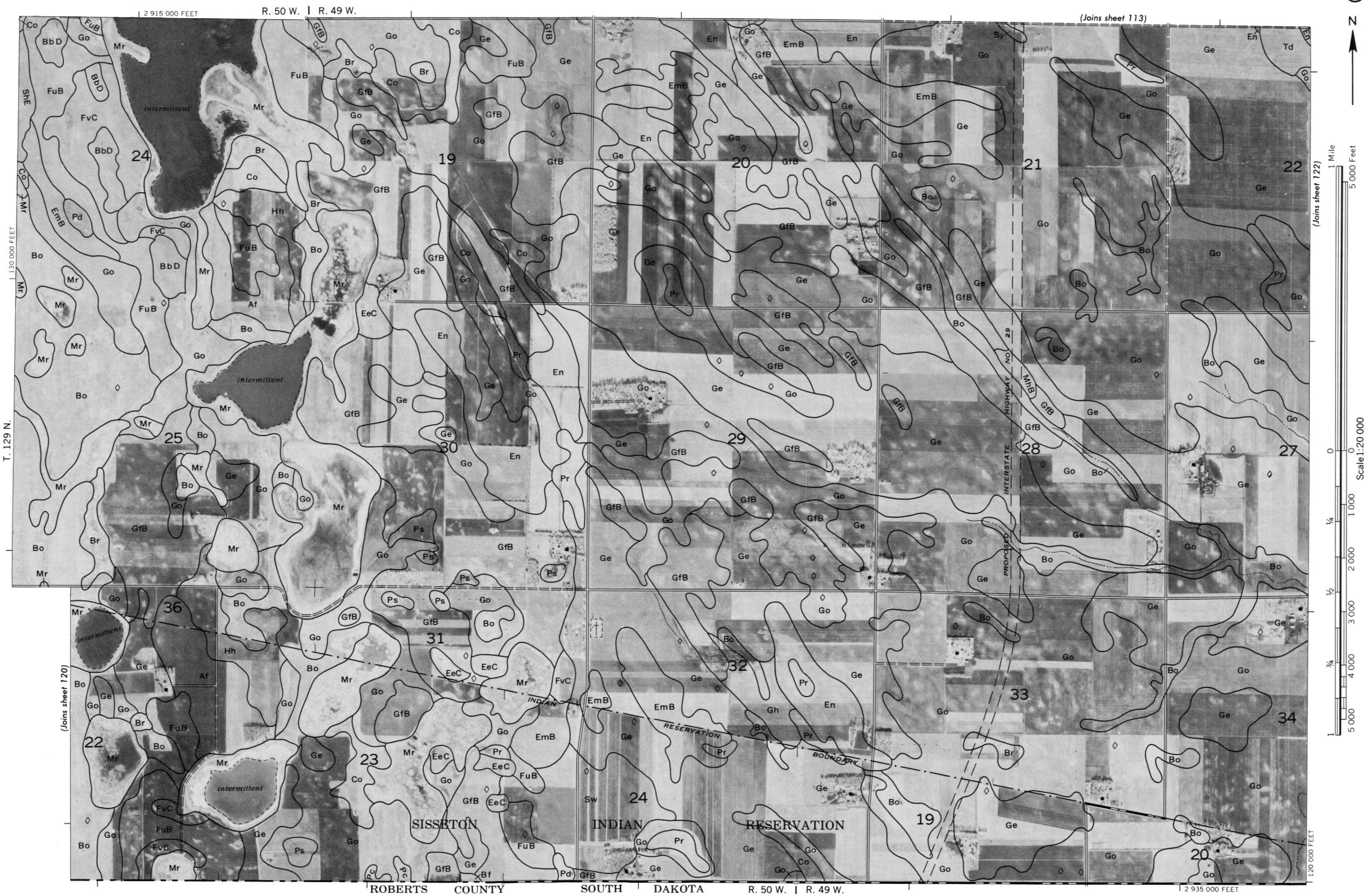


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 120

Land division corners are approximately positioned on this map.

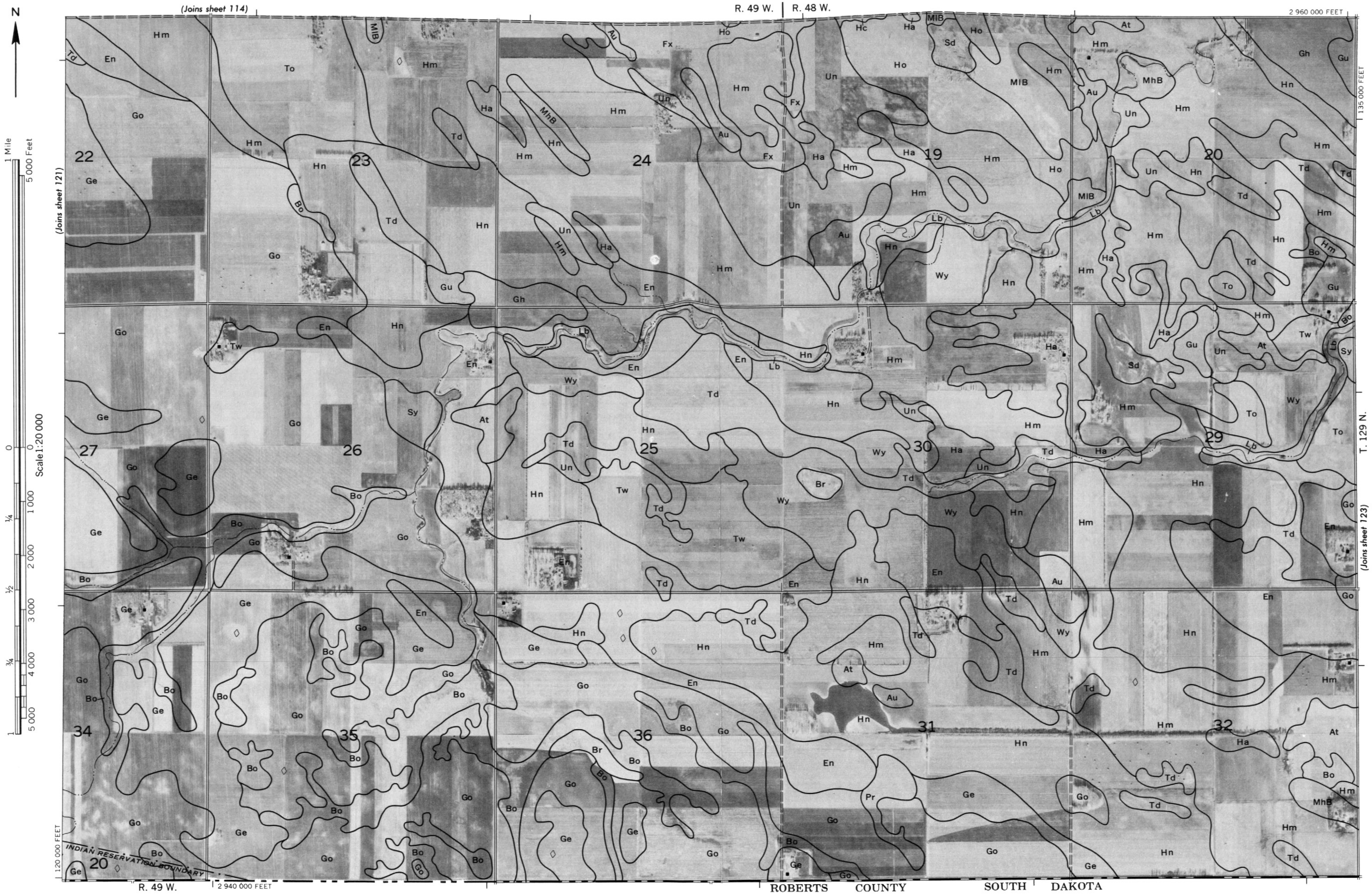
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND COUNTY AND SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM COUNTY, NORTH DAKOTA — SHEET NUMBER 122

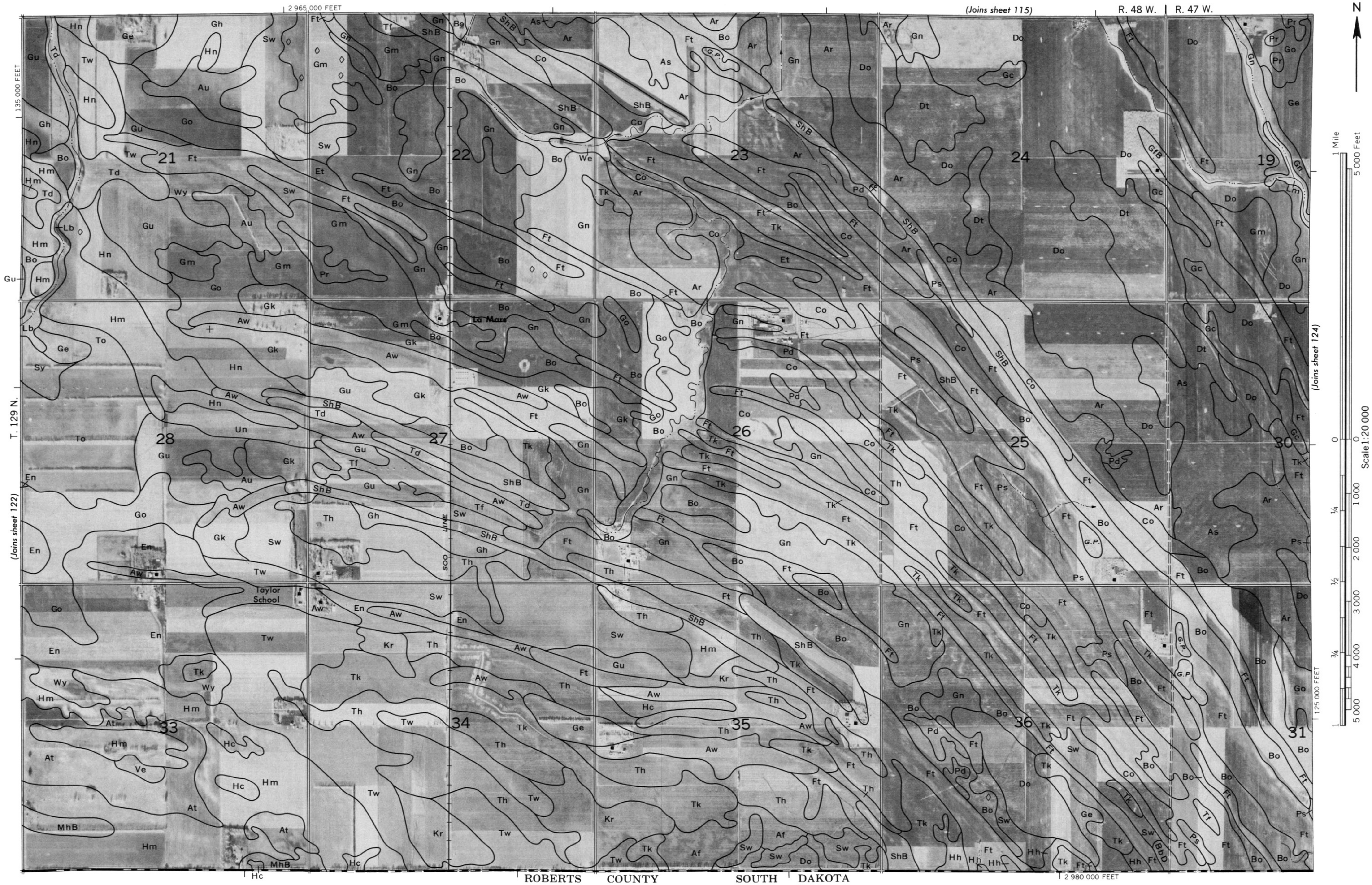


RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 122

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.
Land division corners are approximately positioned on this map.

RICHLAND CO. & SHEYENNE NATIONAL GRASSLAND AREA OF RANSOM CO., N.D. NO. 124

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the North Dakota coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, Forest Service and the North Dakota Agricultural Experiment Station.